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BOTANY.—*The botany and history of* Zizania aquatica *L. ("wild rice").*[1]

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For this evening I have assembled some of my field notes on *Zizania aquatica*, together with some historical data on the species, which I trust will meet the requirements of this occasion. And this is my story.

Life was easy for Wenibozho.[2] His indulgent grandmother, with whom he lived, demanded no work of him, and in consequence he passed through his early boyhood days without exhibiting any particular interest in those things that must be learned and thoroughly understood by people who depend largely upon self for the necessaries of life.

At last, the grandmother awoke to the fact that her grandson lacked the initiative so essential to meet the requirements of their race, and convinced that her solicitous care was responsible, the aging woman urged the indifferent youth to prepare himself with a training that would fit him to endure such hardships as hunger, thirst, and cold. She told him that experiences of this kind would make him resourceful and teach him how to care for himself and those who might be dependent upon him. Probably somewhat irked by these plain words, Wenibozho later said goodbye to his grandmother, who for many years had provided him with food and shelter.

Equipped with only a bow and some arrows, he started on a long journey through the forests. For meat, he had to depend upon the flesh of small animals. Not because there was a scarcity of animals, for they abounded in the woods, but because of his unskilled use of the bow, his kills were few. Therefore, he had to subsist on seeds, roots, and tubers. Without knowing the plants that could furnish nourishing food, he naturally made mistakes.

One day when thoroughly exhausted from want of food he heard a voice saying, "Sometimes they eat us." He heard this voice several

[1] Address of the retiring president of the Washington Academy of Sciences, delivered on January 18, 1940. Received February 12, 1940.

[2] GILMORE, MELVIN R. *Prairie smoke*, pp. 195–198. 1929.

times and finally asked, "To whom are you talking?" A small bush replied that it had spoken. As no part of the bush above the ground seemed edible, Wenibozho thought that the roots might be good to eat. He uncovered the roots, tasted them, and liked the flavor of them very much. Being hungry, he ate many of them and suffered from overeating. For several days he was unable to travel, and when he attempted to do so he found himself as hungry as before and quite weak. As he passed along seeking food, many plants spoke to him. Wenibozho gave no heed to their entreaties until he was attracted by the beauty of a graceful grass growing in a small lake basking in the sunshine of the open woodland. Some of these plants beckoned to him and said, "Sometimes they eat us." He was quite hungry now, and observing that the upper part of the plants was loaded with long seeds, he soon gathered some of them. Removing the hulls, he ate the kernels and found the taste of them so pleasing and their effect upon his hunger so gratifying that he exclaimed, "Oh, you are indeed good! What are you called?" The plants replied, "We are called manomin."

These adventures and discoveries of Wenibozho have served as a foundation for many legends that have been handed down through generations of Chippewa, Menomini, and related Indians. In their childhood, this story excited their imagination, and as they grew older they came to have veneration for this fruitful grass that provides such palatable and nourishing food.

Manomin,[3] an Algonquian word meaning "good berry," is suggestive and descriptive. By most of the tribes of this linguistic stock, this grass and its fruit are called manomin, and by the same name the plant became known to the early white settlers of the upper Mississippi Valley. Many common names for it came into use when the French and English population increased in this region. By the French it was *folle avoine*, a name most frequently found in the earlier accounts of that part of North America around the Great Lakes. The English names for the plant are quite numerous. Such names as wild rice, Indian rice, squaw rice, Canadian rice, black rice, Indian oats, blackbird oats, wild oats, and water oats are found in the literature. This plant, however, is not a species of rice or of an oat, though the vernacular names so designate it. Some of these names are only locally used. For example, this plant is known only by the name of water oats to the older inhabitants living along the tidal streams in the south Atlantic States.

[3] JENKS, ALBERT ERNEST. *The wild rice gatherers of the Upper Lakes.* Ann. Rept. Bur. Amer. Ethnology, 1897–98, 19: 1024. 1900.

Among the adventurers who flocked to North America shortly after Columbus missed his way to India and discovered a new world, there was a sprinkling of naturalists who came to gather seeds and bulbs of plants that might be useful in the gardens, fields, and forests of Europe. Probably the most noted among them was Peter Kalm. Shortly after his return to Sweden he published in 1751 a small octavo pamphlet of 48 pages,[4] containing "a comprehensive summary of his observations on the habitat, use, and care of American plants which he considered of sufficient economic importance to warrant experimental introduction into Sweden." In the text Kalm says: "I have chosen this means to give an index and short account of some of the useful plants [a total of 126 species] the seeds of which I brought home with me from North America where I made a journey at the command of the Royal Academy of Science."

In reference to wild rice, which is included in this collection, he records: "In North America where the plant grows wild, it is used as food by all the savage nations, who yearly collect quantities. Wild ducks are particularly delicious when the rice is ripe, for at that time they live on it almost entirely. If we could succeed in getting this rice to grow and ripen here we would have gained a great deal, for the wettest places would become as productive as fields if the plant would stand our winters. Cattle are more than greedy for the leaves and stalks. The greatest difficulty will be to find a method of sowing seeds so they will germinate. We still know very little about nature's method of sowing the seeds of plants growing in water."

This attempt to introduce this wild plant into Europe was likely a failure, for Lambert, in a paper presented before the Linnaean Society of London in 1804, states that "the seed of [this species] *Zizania aquatica* in a vegetating state from America was long a desideratum among the botanists of this country; for although seeds were received here at different times, yet none of them grew. At last, Dr. Nooth by the desire of Sir Joseph Banks sent them from the lakes of Canada put up in jars of water. As soon as they arrived they were sown in a proper situation, where they came up in a few days and the plants ripened their seeds extremely well in the autumn." This importation of seed was made in 1791.

Resident collectors, among whom may be mentioned Bartram and Clayton, also aided in this work and in addition supplied the botan-

[4] LARSEN, ESTHER LOUISE. *Peter Kalm's short account of the natural position, use, and care of some plants, of which the seeds were recently brought home from North America for the service of those who take pleasure in experimenting with the cultivation of the same in our climate.* Agr. Hist. 13: 34, 43–44. 1939.

Fig.1.—Typical mature plants of the broadleaf *Zizania aquatica* growing in a Potomac River marsh.

ists of the continent with material that greatly enriched the herbaria of many botanical centers of the Old World. In this way a specimen of manomin, called wild rice by the white man, got to Europe, where in 1753 it was described and named *Zizania aquatica* by the Swedish

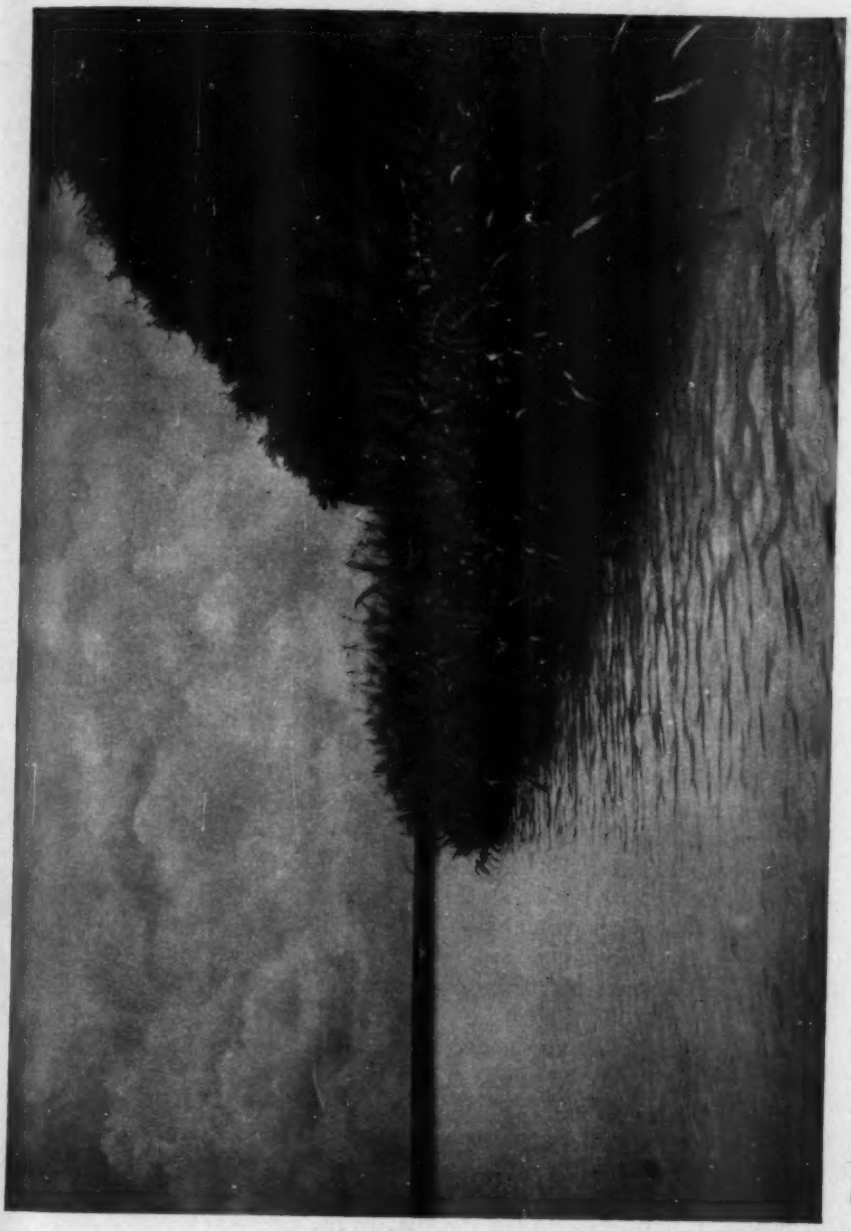

Fig. 2.—The broadleaf *Zizania aquatica* in flower in narrow marsh on east side of Theodore Roosevelt Island (Analostan Island), facing the Titanic Memorial, District of Columbia, August 20, 1935.

botanist Linnaeus. Until then the "good berry" plant was unknown to botanists, although for centuries it had fed many tribes of wild men and for nearly 200 years had supplied the food wants of many European adventurers.

This grass, indigenous to North America, is found from Lake Winnipeg to the Gulf of Mexico and eastward from the Rocky Mountains to the Atlantic coast. Throughout these latitudes, and in this area where conditions are favorable, it is conspicuous among the aquatic plants growing in shallow lakes and in slow-moving streams. In the extreme northern and eastern limits of this region it often covers several hundred acres. Within its natural range the species often occupies the small bays of the large lakes, covers the mud flats on tidal rivers of the Atlantic Coastal Plain, fills the lakelike expansions of rivers near their source, and grows luxuriantly in the quiet bends of sluggish streams. It is seldom found in the inland lakes with no outlets. It grows well on a variety of soils under fresh-water streams and lakes. Its best growth, however, is made wherever the plants can anchor themselves in a thick layer of mud, regardless of the kind of soil.

Zizania aquatica is an aquatic, annual, self-sowing grass having tall, erect, cylindrical, and hollow stems, which bear the inflorescence and 4 to 6 long leaves with flat blades, conspicuously marked by a very thick midrib (Fig. 1). The slender stems have a comparatively thin wall, and when seen by transmitted light, thin, transverse partitions are revealed, dividing the internodal space into compartments, which give the stems a light banded appearance.

The stems vary in height from 5 to 10 feet and in diameter from one-fourth to five-eighths of an inch. The taller plants are characteristic of the tidal flats and the shorter plants of the northern lakes and streams. Plants with stalks as thick as 2 inches near the crown are not unusual in southern marshes. In thin stands and among isolated plants a single plant may have many stems, some arising from the base of the mother stem, though frequently as branches from the first and second nodes.

The principal roots are slender, fibrous, and numerous and do not penetrate deeply into the soil.

The first leaves to appear are long and narrow. In the later and permanent leaves the basal part known as the sheath is thick and spongy in structure and completely wraps the stem, thereby adding much to its rigidity. The sheaths vary in length from 9 to 25 inches.

The blade is the free end of the leaf. In the terminal leaves it may

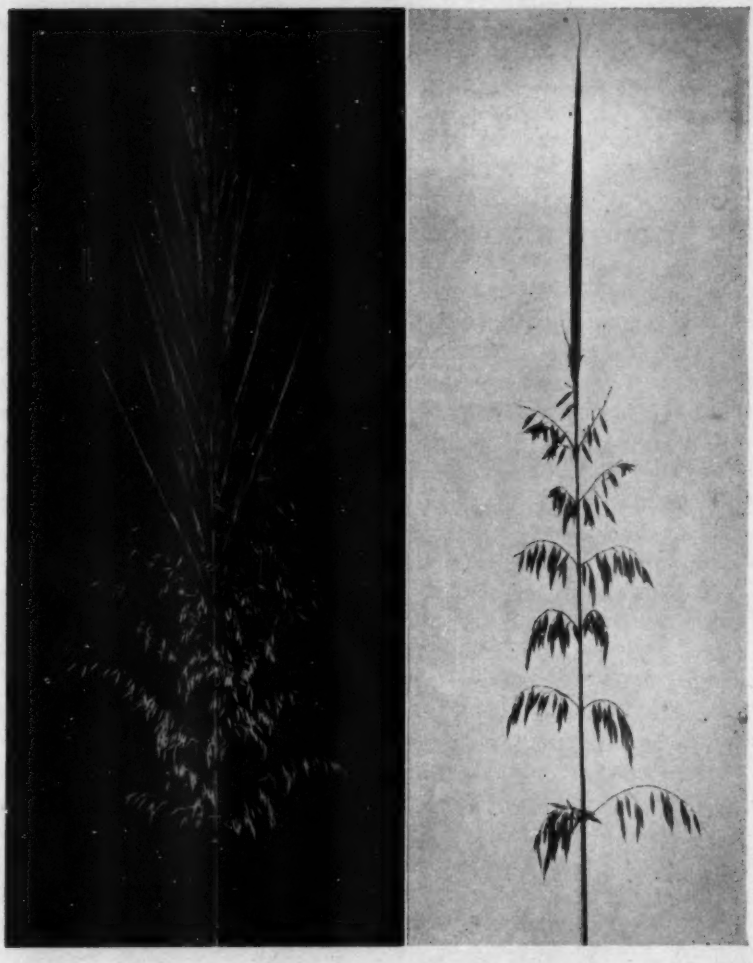

Fig. 3.—Panicles of *Zizania aquatica*. Left: Of the broadleaf form. Its natural length is 26 inches. Right: Of the narrowleaf form. Its natural length is 16¼ inches.

be 2 to 4 feet long and from less than an inch to 1 inch or more wide.

The inflorescence (Fig. 3) is borne on the last node of the stem. It consists of two parts—an upper, with slender straight branches bearing the female or seed-producing flowers, and a lower, with drooping branches bearing the male flowers.

The female flower is very simple in structure, consisting of lemma

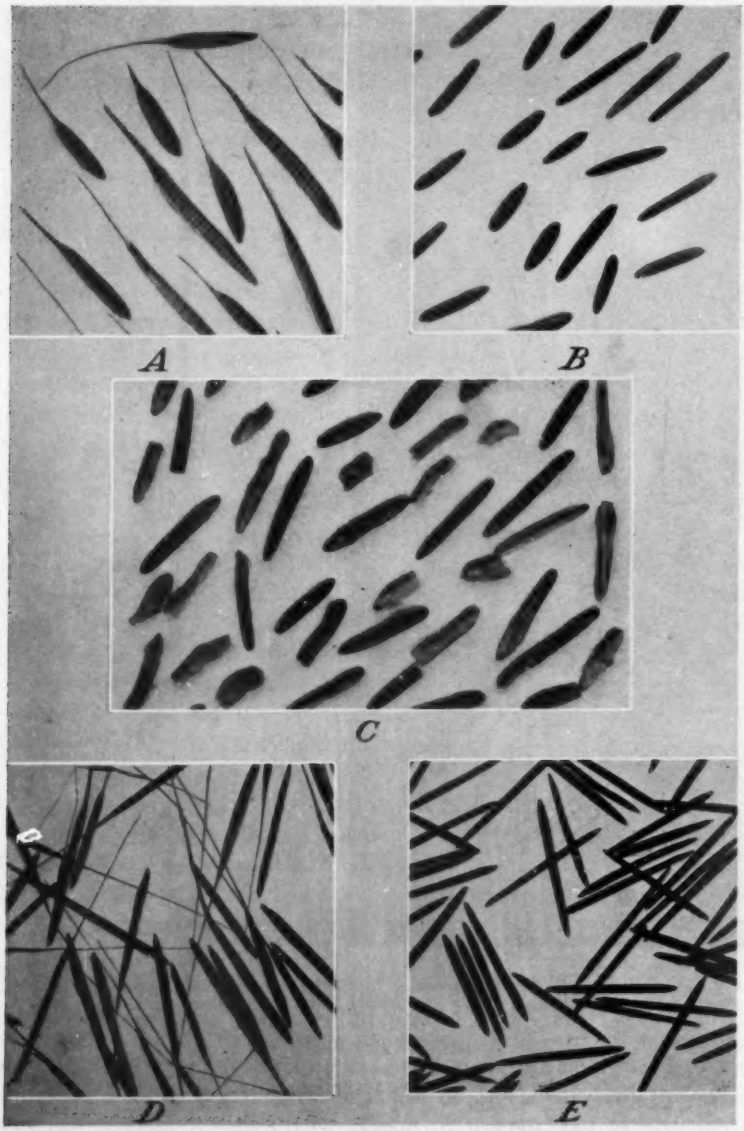

Fig. 4.—Seeds and kernels of *Zizania aquatica*. (Natural size.) Narrowleaf form: *A*, seeds; *B*, kernels; *C*, parched kernels. Broadleaf form: *D*, seeds; *E*, kernels.

and palea that enclose a much-branched stigma and a comparatively small ovary. The lemma bears a long awn or beard. In the male flower, there are also a lemma and palea, which are much shorter than in the female flower. They enclose six bright yellow stamens.

The seed is long and slender and almost cylindrical (Fig. 4, *A*, *D*). A thin brown hull made up of the lemma and palea encloses the kernel and bears a long, stiff, straight awn that is covered with numerous barbs or bristly hairs. The surface of the hull itself is covered with similar hairs.

The kernel of the southern plants averages 20 mm in length and 1.4 mm in width (Fig. 4, *E*). In the northern plants the kernel has an average length of 12 mm and a width of 2 mm (Fig. 4, *B*). There is a shallow groove on the ventral surface of the kernel in which a long embryo is concealed. When fully matured the kernel is purplish black in color.

Zizania aquatica has two rather distinct forms, and within each there are many variants. The form having broad leaves and long needlelike kernels grows along the tidal rivers emptying into the Atlantic Ocean and is also found locally in the interior as far north as southern Minnesota and Wisconsin. The form with narrow leaves and short thick kernels grows in the upper Mississippi Valley and eastward along the Canadian border.

In ascending a tidal stream such as the Potomac River, which is salty or brackish almost to the head of tidal water, the halophytic vegetation begins to disappear with the appearance of *Scirpus americanus*, a fresh-water rush quite resistant to brackish conditions. As the conditions become less saline, fresh-water plants begin to occupy the marshes, and principal among them is *Zizania aquatica*. If the *Zizania* marsh slopes gradually into a slow-running stream, several distinct zones of plants will be present. The deeper water will be inhabited by several species of *Potamogeton*, *Vallisneria spiralis*, and such free-swimming plants as *Lemna* and other duckweeds. In water less than 5 feet in depth, the yellow pond lily may occur.

The next zone is usually narrow and is populated with the pickerel weed *Pontederia cordata*, which grows in approximately 2 feet of water. Having a very large root system it is capable of holding its place in a moderate current and serves as a protection to the adjoining zone containing *Zizania aquatica*, the plants of which are not strongly anchored in the soil. Although such a marsh is inundated, the depth of water covering it varies with the condition of the tides.

The *Zizania* zone is broad and usually parallels the stream for some distance (Fig. 2). The luxuriant growth of *Zizania aquatica* shades out most of its competitors, leaving it in possession of the land except where the stand is thin on the margin of the stream. Here straggling plants of *Polygonum sagittatum* and species of *Sagittaria* and *Bidens* are sometimes present. On the land side of this zone the dominant species is *Typha latifolia*, which under conditions of less water and greater silt deposit may displace *Zizania aquatica*. The *Typha* area itself is soon invaded by *Peltandra virginica*, *Iris versicolor*, and several species of *Hibiscus* and *Polygonum*. As the marsh becomes more elevated and drier, shrubs and finally trees become dominant.

In the lakes of Minnesota and Wisconsin, just beyond the zone containing such submerged plants as the *Potamogeton* species and *Vallisneria spiralis*, the bottom is often thickly covered with plants having lime-encrusted leaves and stems called stoneworts. The *Zizania* area is usually bordered on the outside margin by several species of *Scirpus*, never by *Pontederia cordata* as along the Potomac River, and on the land side by *Carex*, though *Typha* is often present.

During early April in the vicinity of Washington, D. C., the seedlings of *Zizania aquatica* have already emerged from the muck-covered flats and are strong enough to stand erect when the tide is out, like seedlings in any grainfield. Within a week or 10 days after emergence the young plants have three leaves. Growth is slow at first largely because of the low temperature of soil and water and intermittent sunshine. During these days they are strengthening their grip upon Mother Earth, for good anchorage in the soil at this time reduces the hazard of being washed away by tides, especially the ebb flow. The protection of the marginal plants that they have in later life is lacking now. The plants become more robust as spring advances, and by June, where the stand is good, the growth gives the marsh the appearance of a low meadow. In another month the stems that have been concealed by the enveloping leaf sheaths during this vegetative growth begin to give some evidence of their existence.

The part of the stem embraced by the sheath of the last leaf is growing rapidly now and being confined within a narrow space distends the sheath into a spindlelike appearance. Ten days after the inception of this condition is perceptible, the panicle, which is the terminal of the stem, begins to emerge. The panicle emerges slowly, often requiring seven days to free itself from this cover. It carries on its distal end the female flowers that bloom almost immediately upon

emergence. They, at once, are receptive to wind-borne pollen from nearby or distant plants, for the male flowers of the same plant are still within the leaf sheath.

The male flowers on the lower part of the panicle hang like elongated purple bells, which open a few days later, revealing six yellow bodies like so many clappers, which are filled with pollen that is soon discharged into the air to be carried by the wind to other plants. This pollen takes no part in the fertilization of the female flowers of the same flower cluster. The male flowers on long drooping branches arranged in whorls add beauty and symmetry to this tall, slender, stately plant attractively dressed with long, broad, hanging leaves.

The slender, flexible panicle, when fully protruded, may be 30 to 50 inches above the terminal leaf. On its topmost branches the seeds are developing very irregularly. As they approach maturity, which normally occurs within 15 days after fertilization, the seeds drop very readily, passing quickly through the water to the mud bottom below. They do not float and are soon anchored in a soft bed by the many bristlelike hairs on their outer surface. These structures, by their number and arrangement, serve to fasten the seeds more securely in the mud. Here they lie until the following spring, when the majority of them germinate.

Zizania seed can not be kept in dry storage like other seed. To retain its viability it must be kept in a wet state and at a temperature that will prevent fermentation and control germination. There is no harvesting of this seed in Eastern United States for human use. Many birds, however, feast upon it and in so doing assist in the natural sowing of enough seed to provide for next season's crop. The dense brown mat of fallen plants and crumpled foliage, which soon covers the marsh, will again look green in spring when the young plants, sprouting from this self-sown seed, push their way through and above this organic debris.

The birds that feed upon this maturing grain are the bobolinks and red-winged blackbirds. Late in August and early in September these birds may be seen in large flocks settling on the plants of *Zizania aquatica* at meal time, which continues throughout the day. The wading birds, such as the sora, feed upon the fallen seeds that lie in shallow water, or exposed on the ground, when the tide is out. Many species of diving ducks feed upon the seed that has settled in the mud.

The center of the largest area of this uncultivated grain is in the region of the adjacent sections of Minnesota, Wisconsin, Manitoba, and Ontario, which is crowded with alluvial bottom lakes, serving as

sources of many rivers that for great distances meander through a flat country and give the landscape the appearance of one immense marsh. The Fox River, on which the earlier explorers traveled from the Great Lakes region to the Mississippi River, may be taken as typical of such streams, filled for the greater part of its length with *Zizania*. The Indians[5] tell us that this river was made by a monstrous serpent that spent the night in the marshes between Lake Winnebago and the Wisconsin River. Having obtained during the day enough food to satisfy its hunger, this creature at dusk crawled in among the vegetation covering this low land to sleep off the lethargy that accompanies a full meal. While it slept, the dew accumulated upon its body. At sunrise it awoke and shook the moisture from its back and in it wriggled toward the larger lake, leaving behind a chain of small lakes that now are expansions of the river that became the waterway to the great Northwest. In his account of ascending this river in 1673, Marquette says, "The way is so cut up by marshes and little lakes (Fig. 5) that it is easy to go astray, especially as the river is so covered with wild oats [*Zizania aquatica*] that you can hardly discover the channel. Hence, we had good need of our two guides."

In many places throughout this region such conditions exist today, in normal seasons, from the middle of June until the first of October. When the waters are free of ice, usually about the middle of May, *Zizania* seed begins to germinate. Most of it was sown by nature early in autumn of the preceding year and some of it through accident by the Indians themselves in spite of their skill in harvesting the crop.

The seedlings grow very slowly at first, too weak to stand erect without the support of the water, which not only surrounds but covers them, often deeply. During this early growth, with their narrow leaves floating and reaching upward and outward, the plants appear, when seen from a canoe floating over an old *Zizania* bed, like so many hydrae seeking their prey. In less than a month the young plants push their leaves to the water surface, spreading them upon it in long streamers, which at a distance upon good light conditions give the lake the appearance of having a low verdant island. In approaching small beds of this plant, the emerging leaves could be taken, even at a short distance, for a thick growth of duckweeds. In this stage of growth, the plants are greatly exposed to wave action. By it they may be detached from the soil and brought to the surface of lake or stream, leaving only open water where a few days before the young

[5] THWAITES, REUBEN GOLD. *Historic waterways*, p. 153. 1888.

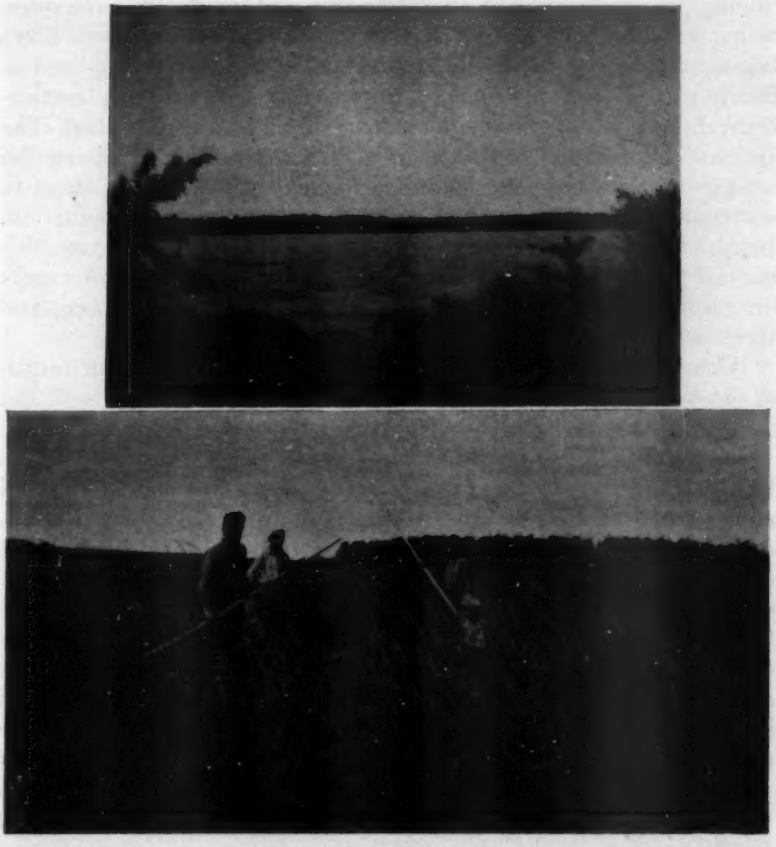

Fig. 5.—Upper: A small lake in northern Minnesota filled with *Zizania aquatica* ("wild rice"). It has the appearance of a low meadow. August 1938. Lower: Young Chippewa Indians, in boats, have just finished harvesting "wild rice" in a Minnesota lake. The plants are still erect and there is no open water to be seen. September 1938.

plants gave the area the appearance of a green field. Entire stands covering a hundred acres or more are often destroyed in this way. When water and weather conditions are favorable, the plants are strong enough in July to push their stems upward. A few weeks later the flower clusters begin to emerge. The stems are stronger now and have become more erect. Continuous sunshine and a mild temperature ripen the seed in about three weeks.

Among the Indians about this time the topic of conversation is

"ricing," a word coined by the white man and used only in reference to harvesting this grain. The urge to assemble at their favorite lakes begins now to grow upon these people. They drift in singly and in family groups, settling usually in a wooded spot overlooking the ricebeds. In a few days a camp of many families is established. The Indians' information on the crop is rather definite, for during the season the rice-producing lakes are frequently scanned by them to ascertain the stand, vigor of plants, and probable seed production. Besides their interest in the crop as a source of food and revenue, this harvest time is the great social event of the year. Within these camps life presents a picture that is quite primitive even though here and there are evidences of contact with the white man's world.

When it becomes known after an inspection that about one-fourth of the seeds appear ripe, the men and women and the older boys and girls take to boats (Fig. 5).

The grain is harvested from canoes that may or may not be the handiwork of Indians. Narrow flat-bottom boats, made of planks and pointed at each end, are also used. These are made by the Indians and are as expertly handled by them as the canoes. Either type of craft is preferred to broad-bottom boats. The latter kind, because of difficulty in handling, destroys many plants and shatters much grain that would be gathered from a boat more easily handled. In using the narrow boats the gatherers may return to the crop as the seed ripens and this may be done two or three times. With the broad-bottom boats, which are used by the white men, only one passage over the ricebeds is ever made.

Our cultivated grain ripens rather uniformly, but not so with this wild plant. The harvest in a certain locality may extend over a period of two to three weeks when weather conditions are favorable and when the crop is in the hands of Indians. The white man who gathers this grain is not a conservationist. By heritage the Indian is.

Each craft is occupied by two persons, one who stands in the stern, using a long forked pole to push and guide the boat slowly among the plants, and the other usually a squaw, who gathers the grain, seated near the middle of the boat, facing the bow. With two small pointed sticks, about 30 inches long, one in each hand, the seated person runs one of the sticks into the plant growth, bending a few plants over the boat, and strikes the grain-bearing part of the panicles with the other stick quickly and lightly. The grain, which is easily dislodged, drops upon the covered bottom of the boat or canoe. This performance is repeated on the other side of the boat and continued alternately

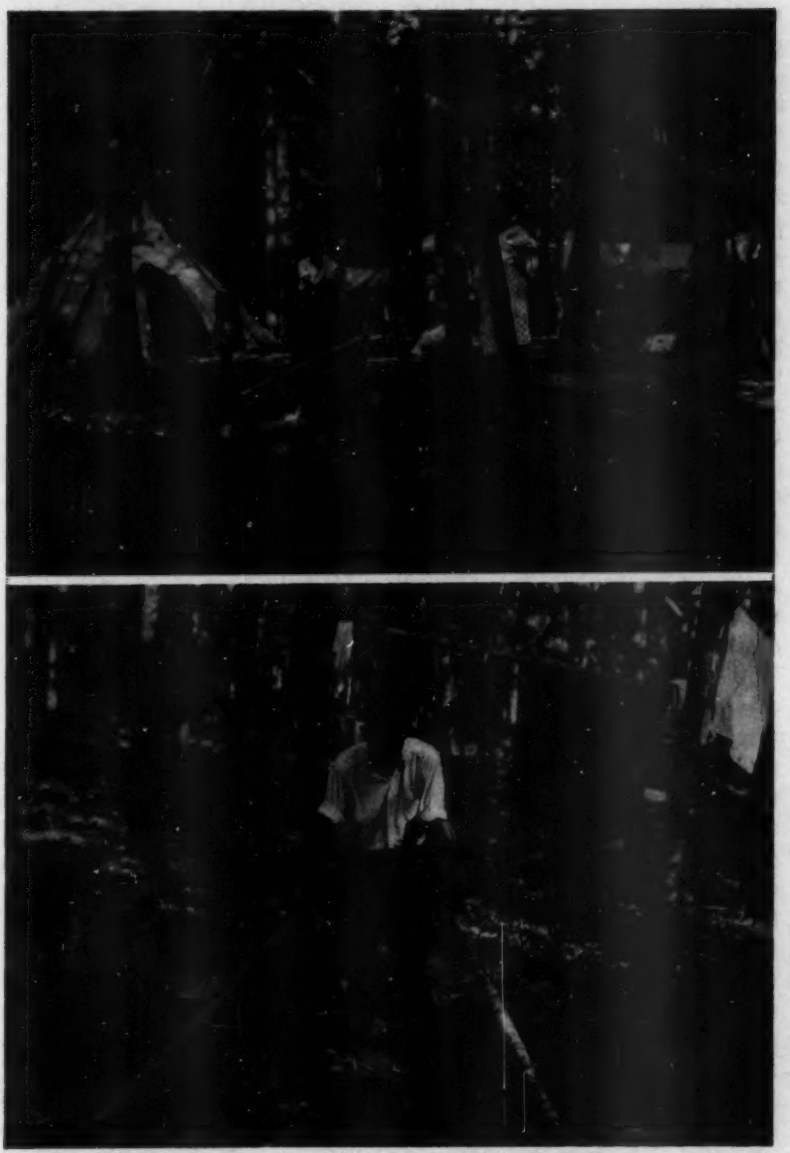

Fig. 6.—Upper: A Chippewa woman parching "wild rice" in a typical Indian camp, northern Minnesota. September 1923. Lower: A Chippewa Indian hulling ("jigging") parched "wild rice" in a typical Indian camp, northern Minnesota. September 1923.

while the boat is moving until 75 to 100 pounds of seeds have been gathered.

The harvested grain can not be kept perfectly dry while in the boat. The added moisture is usually driven off by thoroughly airing the grain, spread out in the sun on skins, birch bark, blankets, or canvas. After the grain is dried in this manner for several days, though sometimes this step is omitted, it is put into a large iron kettle or a galvanized iron tub, about 25 pounds at a time, and parched slowly over a wood fire, being constantly stirred with a paddle to prevent burning (Fig. 6). Parching requires from 15 to 25 minutes, depending upon which of the above containers is used. The grain parched in the iron kettle requires more time for this process and usually is a better quality than that parched in a tub, probably owing to the fact that a uniform heat is more easily maintained in the former than in the latter.

The grain is now ready for the most primitive kind of a mill. This equipment, which may be termed a mortar, is a hole in the ground about 1½ feet wide and 2 feet deep and lined with a skin. When ready to operate, about 20 pounds of the parched grain is poured into this receptacle. A buck Indian (Fig. 6), taking the part of a pestle, steps upon this loose pile of grain and with a half jump on one foot and then on the other, combined with a kind of shuffle, treads out the kernels. While supplying this power the Indian supports himself by poles driven into the ground near the hole. This process, usually called "jigging," detaches the hulls and completes the milling.

The mixture of kernels and hulls taken from the skin-lined hole is now put into a birch-bark tray, about 30 inches long, 20 inches wide, and 6 inches deep, to be separated by means of the wind. A windy day is usually used for this purpose, yet in the hands of a skillful squaw the tray without the aid of wind becomes a very efficient fanning mill. The operator, while standing, holds the partially filled tray even with her waist and slightly inclined. At regular intervals she tosses the contents of the tray. After each toss, the kernels tend to fall toward the lower side of the tray and the hulls toward the upper side. After this partial separation the mixture is tossed higher into the air, and at the same time with a quick movement of the wrists the tray is turned forward, producing enough wind to throw much of the chaff several feet away. This operation is repeated until the chaff is completely removed. If the grain was fully matured when gathered and the hulls loosened and detached by parching and "jigging," this primitive method of cleaning leaves only the heavy kernels, which,

after washing in several changes of water, are ready for cooking (Fig. 4, *C*).

Some new methods of preparing the grain, brought about through intercourse with the white man, are gradually being used by the Indians. The primitive method of parching and hulling, however, although it does take time and labor, produces a product superior in quality to that so far obtained by the white man. The use of modern machinery for cleaning in place of the birch-bark tray could be used to advantage and is now being considered by dealers who are seeking larger markets for this cereal.

The Indians known as wild-rice gatherers belong to the two great linguistic stocks,[6] the Algonquian and the Siouan. The former includes the Chippewa, Menomini, Cree, Fox, and other small tribes. Among the latter the principal tribes are the Sioux, Winnebago, and Assiniboin. Probably the Menomini and Winnebago were the first important tribes to enter the eastern border of the great wild-rice country, for when found by Nicollet in 1634 they were well established in the vicinity of Green Bay, an area now within the State of Wisconsin. They had migrated from the Atlantic seaboard.

According to Indian tradition the Menomini tribe has been identified with wild rice for remote ages. Their name is usually translated to mean "wild-rice people." It has been their belief that "whenever the Menomini enter a region the wild rice spreads ahead, whenever they leave it the wild rice passes."[7] In their economy agriculture had a very minor place. They lived almost exclusively on game and on plants requiring no cultivation. They put a high valuation on wild rice and considered it a gift from the spirit powers, and therefore it has always been an essential basis for their ceremonial feasts and offerings.

In 1852 the Federal Government assigned to this tribe a large timber tract on the upper Wolf River as a permanent reservation. Here they are today, no longer "wild rice people" but foresters engaged in lumbering, having a tribally owned mill at Neopit that has been in operation since 1908. Within their reservation there are a few wild-rice patches, but they receive no attention because they are too small to produce a worth-while crop. Although the Menomini do not gather wild rice today, they still use it ceremonially.

The Winnebago Indians were less nomadic than the other Siouan tribes and lived near the waterways in preference to a life on the plains, which the Sioux enjoyed so much. For food they, like the

[6] JENKS, ALBERT ERNEST. Op. cit., p. 1038.

[7] KEESING, FELIX M. *The Menomini Indians of Wisconsin.* Mem. Amer. Phil. Soc. 10: XI+261. 1939.

Menomini, depended upon fish, small mammals, wild rice, maple sugar, and berries.

When the Chippewa, one of the largest tribes north of Mexico, began to move westward, they were driven forward by the Iroquois, who occupied land that was not overstocked with game but well suited for cultivation. These newcomers, being hunters, were not welcome by the tillers of the soil and were forced by circumstances to continue westward. As the Chippewa moved onward, they encountered the eastern bands of the Sioux tribe occupying the lake region now a part of Wisconsin and Minnesota.

This part of the great central valley of this continent is filled with innumerable shallow lakes and sluggish streams that at one time contained an unfailing supply of food. To the red man centuries ago this region was a hunter's paradise. Besides wild rice and fishes and other water-inhabiting animals, it contained for the aborigines an inexhaustible supply of land animals too, the flesh and hides of which provided food and clothing. These natural resources were considered by the Sioux who first possessed them and by the Chippewa who desired them as tribal property of the greatest value, and each fought fiercely to get control of them. To these gifts of Nature should be added the beautiful and useful birch, the bark of which the original inhabitants and their descendants have used to cover their lodges, wigwams, and canoes. The bark of the basswood, too, has contributed much to the wants of these people.

Without a decisive engagement at any time, the struggle between these tribes for the full possession of this country continued at intervals for several centuries until 1862, when the Government removed the Sioux.

The Chippewa never had an undisputed control of these lakes, though for several hundred years they ventured upon them to gather wild rice, often at the cost of a heavy loss of life. The Indian who gathers wild rice in the United States today is of this tribe. His appraisal of these lakes and woodlands made centuries ago has not changed with the years. So, on many occasions, when new treaties had to be made to gratify the greed of the white man, the Chippewa Indians have asked our Government to give heed to their needs.

As late as 1863, Hole-in-the-Day, the leading chief of the Chippewa, addressed a pathetic appeal to the Great Father at Washington, which, in part, is as follows:[8]

[8] Report of the Commissioner of Indian Affairs for the year 1863, pp. 328–331.

My people are unhappy and dissatisfied. I want to see them happy and contented. It is both to their interest and the interest of the white man that they should be so, and they require but little to make them so. * * *

The present treaty gives us little but swamps or marshes, where locations can be selected that combine all these elements of comfort and content to our people, that is, good land, game, fish, rice and sugar. Here, we have neither to any considerable extent. True, we may find a little rice and a few fish, but not sufficient for my people, not enough to save them from starvation. If a treaty were made with the Red Lake Indians, a tract of country of the best character for my people might be secured without any outlay of expense to the government: say that strip of land lying on the Wild Rice River between the 47° and 48° north latitude and east of the Red River. There is every advantage of good soil, game, fish, rice, sugar, cranberries and a healthy climate. * * *

This late treaty never will, never can satisfy our people. A reservation on the Wild Rice would satisfy them all, and they would leave their present homes and go to their new ones happily and with a feeling that a better future was before them. * * *

The sooner this is done the better, as it would have a tendency to quiet the discontent now existing among our people generally, by holding out to them a prospect of a good and pleasant home somewhere near or in the valley of the Wild Rice. * * *

Believe me, then, my Father, to be what my people always have been and what they and I now am, Your friend and the friend of the white man.

Wild rice has played an important part in providing subsistence to explorers and trappers who penetrated this great continent two or three centuries ago along the waterways that now separate the United States from the Dominion of Canada.

A traveler among the North American Indians during the years 1652 to 1684, after referring to his reception by the natives, states, "Our songs being finished we began our teeth to worke. We had there a kinde of rice, much like oats. It growes in the watter in 3 or 4 foote deepe." After comments on God's care over His creatures and a brief description of how the grain is gathered, he continues: "That is their food for the most part of the winter and doe dresse it thus: ffor each man a handfull of that they putt in the pott, that swells so much that it can suffice a man."[9]

In his *Travels and adventures in Canada and the Indian Territories*, Alexander Henry[10] tells us a hundred years later about obtaining from Indian women by barter 100 bags of this grain and adds that "without a large quantity of rice the voyage could not have been prosecuted to its completion."

[9] *Voyages of Peter Esprit Radisson.* Transcribed from original manuscripts in the Bodleian Library and the British Museum. The Prince Society, Boston, 1885.

[10] HENRY, ALEXANDER. *Travels and adventures in Canada and the Indian Territories, 1760–1776*, new ed., p. 241. 1901.

An ample supply of wild rice was always included among the winter provisions for the outposts of the fur companies trading in this region. David Thompson[11] records in his *Narrative of explorations in western America* that a superintendent of a fur company in northern Minnesota and his men "passed the whole winter on wild rice and maple sugar." Under such circumstances he considered this grain "a weak food" and says that "those who live for months on it enjoy good health and are moderately active but very poor in flesh."

The old journals of the earlier hunters, trappers, and priests seeking adventure in this great wilderness of the north contain many stories about the use of this grain in fighting hunger when other food was hard to get. In the great outdoors, white men, like Indians, can retain health, develop endurance, and enjoy life on a very simple diet.

The aborigines of this country were fond of soups, broths, and stews thickened with wild rice.[12] To this day, their descendants have not lost that fondness. In addition to its simplicity, this dish has the character of elasticity, which appeals to the Indians. With them mealtime is often visiting time. A meal started with three people may be increased to ten or more before it is finished. The uninvited guests never seem to cause embarrassment. To provide for them it is necessary only to add water to increase the volume of the soup.

With a squaw as a cook a favorite dish in the camp of rice-gathering Indians has been wild rice, corn, and fish boiled together, called "Tassimanonny."[13] This combination of foods has also tickled the palate of the white man, as may be judged by the enthusiasm of one who spoke of it in his later years as being "an object of early love." The Indian likes sweets and often eats his boiled rice with maple sugar.[14] He may also flavor his boiled rice with cranberries and his soup with blueberries. Boiling does not, as a rule, reduce the kernels to a paste, but should this condition occur, the pastelike mass is used by the Indians as a substitute for bread.[15]

Some Indians parch wild rice until the kernels burst open as popcorn does when heated, and eat it in this condition when away from camp.[15] Because of its keeping qualities, the parched grain is recom-

[11] THOMPSON, DAVID. *Narrative of explorations in western America, 1784–1812.* The Champlain Society, Toronto 1916.

[12] SMITH, HURON H. *Ethnobotany of the Meskwaki Indians.* Bull. Publ. Mus. City of Milwaukee **4**: 259. 1928.

[13] BIDDLE, JAMES W. *Recollections of Green Bay in 1816–1817.* Appendix No. 4. First Ann. Rept. and Collections of the State Hist. Soc. of Wisconsin for the year 1854, **1**: 63.

[14] DUNBAR, SIR GEORGE. *Other men's lives,* p. 149. 1938.

[15] STICKNEY, GARDNER P. *Indian use of wild rice.* Amer. Anthrop. **9**: 115–121. 1896.

mended to vacation campers for use in either the dry or boiled state. In the land of "Ten Thousand Lakes" where the parched grain is comparatively cheap and is usually a part of the daily meal, the woodman has the advantage of the man of the city, who must pay exorbitant prices for it to cover handling charges and profits. Under these circumstances wild rice in the city home is seldom used except on special occasions.

Knowing how some like the grain, we may assume that all would be just as enthusiastic "ffor each man a handfull of that they putt in the pott" and would exclaim with Wenibozho, "Oh, you are indeed good!"

PALEONTOLOGY.—Paralbula, *a new fossil fish based on dental plates from the Eocene and Miocene of Maryland.*[1] S. F. BLAKE, Washington, D. C.

In the fall of 1935, my wife, Doris H. Blake, found a nearly perfect specimen of the crushing dentition of some fish on the shore of the Potomac River at Liverpool Point, Charles County, Md. The deposits exposed in the bank at this place belong to the Piscataway member of the Aquia formation (Lower Eocene), and the specimen, although not found in situ, can be attributed to this period with as much confidence as the teeth of *Lamna obliqua* and other sharks found in abundance on the Potomac shore at the same locality. The specimen was given to the U. S. National Museum and has since been recorded and figured by Dr. George S. Myers.[2] Dr. Myers identified the specimen as one of the Albulidae (ladyfishes), which he regarded as including among living forms only two monotypic genera, but he refrained from giving a name to the specimen or even assigning it to a genus because the crushing tooth plates of the two existing genera are not distinguishable.

The nearly perfect condition of this specimen and the fact that it was the first fossil representative of the Albulidae to be recorded from America, with the exception of a scale from the Cretaceous of Florida described as *Albula antiqua* Cockerell,[3] seemed to make it desirable to assign a specific name to it, if only to prevent it from being overlooked. Examination of the pertinent literature and of alcoholic specimens of *Albula vulpes* kindly made available by Dr. L. P. Schultz soon showed that this dental plate could not be referred to either of

[1] Received January 12, 1940.

[2] MYERS, G. S. *A third record of the albulid fish* Dixonina nemoptera *Fowler, with notes on an albulid from the Eocene of Maryland.* Copeia 1936(2): 83–85, fig. 1. 1936.

[3] Copeia 1933: 226. 1933.

the recognized existing genera of the Albulidae. In *Albula*, the best-known representative of the family, the lower dental plate is twice as long as wide, or more, and bears only a single layer of teeth, which on dropping out leave a circular rounded-out pit in the surface of the supporting bone. This description applies to the fossil species, two of which are described from the Eocene of England, and one from that of Nigeria, as well as to the living one. The Maryland fossil is much wider in proportion to its length, and its teeth are superposed in irregular piles of 4 to 6, or probably more in the center of the plate, and on breaking or wearing they do not leave a cavity but are replaced from beneath, as in *Phyllodus* and some other genera of fossil fishes. The teeth, moreover, as shown in the accompanying sketches, are quite different in structure from those of *Albula*.

In superficial appearance the plate in question is very similar to the original illustrations of *Egertonia*, a genus described by Cocchi from the Eocene of England. Errol I. White, of the British Museum, to whom an enlarged photograph was sent for comparison with the type of *Egertonia*, reported that the latter is very different, the teeth resembling those of the related *Phyllodus*, being very thin, usually only slightly convex, with very numerous successors in piles, while both upper and lower plates are sigmoid in profile. Mr. White regards the Maryland specimen as representing an apparently undescribed genus, which may bear somewhat the same relationship to the albulids that *Labrodon* does to the labroids and *Diaphyodus* to the sciaenids—that is, a fossil form with pharyngeal dental plates similar in general to those of living forms, but having each tooth subtended by a pile of successional teeth. Its assignment to the Albulidae, however, must be regarded as only tentative.

Paralbula Blake, gen. nov.

Pharyngeal dentition similar to that of *Albula*, but each tooth with a pile of subvertically arranged successors.

Type species, *P. marylandica*, n. sp.

Paralbula marylandica Blake, sp. nov.

A nearly oval lower pharyngeal dental plate measuring 35 mm in length, 26 mm in width, and 11 mm in depth, broadly rounded at anterior end, subtruncate behind, convex-rounded on the oral surface, somewhat flattened along midline especially posteriorly, slightly concave on the attached surface. Triturating surface densely covered with jet-black, shining, subcircular, depressed-hemispherical teeth, about 141 in all (including bases of broken-off teeth), not arranged in definite lines, the central ones 3.2–3.5 mm in diameter, the lateral gradually decreasing in size, the outermost 2–2.5 mm in diameter. The teeth are irregularly superposed in several layers separated by bony tissue, not in direct vertical piles, and have a very smooth, rounded,

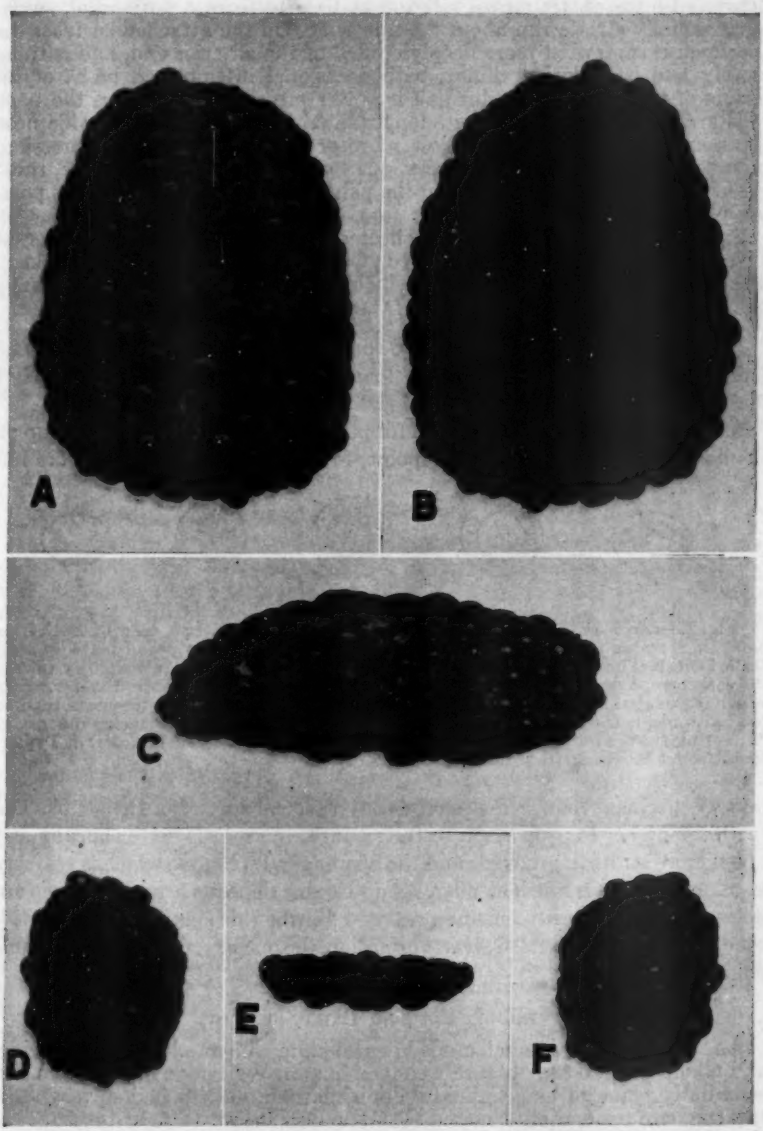

Fig. 1.—A, *Paralbula marylandica*, tritoral surface; B, attached surface; C, lateral view; D, *Paralbula dorisiae*, tritoral surface; E, lateral view; F, attached surface. All × nearly 2.

depressed-hemispheric crown inflexed at base to form a horizontal, somewhat radially striate rim about 0.5 mm wide. On the attached surface, the specimen is somewhat more deeply eroded at the anterior end, and is there loosely and irregularly cellular, with occasional interspersed bases or interiors of teeth. The posterior half is better preserved and shows the bone cells arranged mostly in definite longitudinal rows, with on each side near the margin of the bone a shallow more or less wedge-shaped depression, bounded in front and on the inner side by a rather indefinite ridge, these evidently being the scars marking the points of attachment to the supporting pharyngeal bones.

Type.—U.S.N.M. no. 13855, collected on shore of Potomac River at Liverpool Point, Charles County, Md., October 13, 1935, by Doris H. Blake. The deposits at this point, from which the specimen undoubtedly came, belong to the Piscataway member of the Aquia formation, Lower Eocene.

In my own collection is a detached tooth with eroded base, measuring 4.5 mm in diameter, and evidently belonging to the same species, which I picked up on the beach at the same locality in 1938.

As this paper was being prepared for publication, Mrs. Blake picked up on the beach near the wharf at Plumpoint, Md., a much smaller and more im-

Fig. 2.—*a–c, Paralbula marylandica*: *a*, Cross section of tooth; *b*, view of tooth from beneath, showing the inflexed rim; *c*, view of scar left on oral surface of plate by a detached tooth. The outer ring, which is somewhat impressed and slants slightly toward the center, represents the area occupied by the inflexed rim of the tooth; the inner ring, which is elevated above the outer, is evidently a ring of denser bony tissue subtending the tooth inside the inflexed rim, and fitting against the somewhat beveled inner edge of the rim; the central circle is cellular bony tissue. *d–e, Paralbula dorisiae; d*, Typical tooth from beneath; *e*, from the side. All ×5.

perfect specimen that seems to represent a second species of the genus. The teeth are higher in proportion to their width, the root is more slanting and much more strongly grooved, and the opening in its center, which is scarcely at all excavated, is much smaller. As no Eocene deposits are exposed within miles of Plumpoint, it seems necessary to ascribe this specimen to the Miocene, and probably to the Calvert formation, the one best developed at Plumpoint.

Paralbula dorisiae Blake, sp. nov.

An irregularly oval, much eroded dental plate 15.5 mm long, 12 mm wide, and about 4 mm deep, obscurely convex in cross section on oral surface and essentially plane in longitudinal section, flattish on attached surface. Triturating surface densely covered with blackish brown to light brown, subcircular, depressed-subspherical teeth, about 40 in all (including bases of broken-off teeth), not arranged in definite lines, 1.5–2.2 mm in diameter, 1.2–1.7 mm deep. Teeth irregularly superposed in about three layers, or perhaps more in the center of the plate, separated by bony tissue, not in

direct vertical piles, with a smooth, almost hemispherical crown and strongly striate, slanting root often almost equaling the height of the crown and tapering to a subtruncate tip 0.8–1 mm wide. The cavity left in the bone by detached teeth is deeper than that in *P. marylandica*, with more strongly grooved sides, and the striated inner ring is not at all elevated; the central area is perforate in all the cavities visible in the specimen.

Type.—U.S.N.M. no. 16134, collected on shore of Chesapeake Bay close to and just south of the wharf at Plumpoint, Calvert County, Md., August 13, 1939, by Doris H. Blake. Probably from the Calvert formation of the Miocene, the best developed formation in the vicinity of Plumpoint.

BOTANY.—*Miscellaneous new American grasses.*[1]

JASON R. SWALLEN, U. S. Bureau of Plant Industry.

During the identification of various collections of grasses in the past few years, the following species were found to be new, three of which are from the United States, i.e., *Poa fibrata*, *Stipa diegoensis*, and *Digitaria albicoma*.

Chusquea sulcata Swallen, sp. nov.

Culmi graciles ramis floriferis fasciculatis adscendentibus 10–25 cm longis; vaginae internodiis longiores, glabrae, in ore hispidae marginibus ciliatis; ligula 0.5 mm longa, truncata; laminae 6–12 cm longae, 4–6 mm latae, acuminatae, glabrae marginibus sparse papilloso-hispidis; paniculae 4–10 cm longae, 5–10 mm latae, densae, ramis brevibus appressis; axis pubescens; glumae minutae obtusae enerves; lemmata sterilia obtusa vel subacuta, obscure 1–5-nervia, 2.5–3 mm longa; lemma fertile 6–7 mm longum, subacuminatum, obscure 7-nerve, exaristatum, glabrum; palea lemma aequans, sulcata, carinis approximatis pubescentibus, marginibus latis; antherae 4 mm longae.

Culms slender, probably clambering, the flowering branches in rather small ascending fascicles, 10–25 cm long; sheaths longer than the internodes, glabrous on the back, hispid in the throat, the margins ciliate; ligule about 0.5 mm long, truncate; blades 6–12 cm long, 4–6 mm wide, acuminate, narrowed toward the base, glabrous, sparsely papillose-hispid on the margins; panicles 4–10 cm long, 5–10 mm wide, rather dense, the short branches appressed, floriferous to the base, the axis glabrous or obscurely scabrous on the angles; glumes minute, obtuse, nerveless; sterile lemmas obtuse or subacute, apiculate, 1–5-nerved, the lateral nerves often obscure, $\frac{1}{3}$ to $\frac{1}{2}$ as long as the floret; lemma 6–7 mm long, subacuminate, obscurely 7-nerved, awnless, glabrous; palea as long as the lemma, sulcate, the keels close together, pubescent, the broad glabrous margins enclosing the flower; anthers 4 mm long.

Type in the U. S. National Herbarium, no. 1722000, collected on Mount Orando, Chiapas, Mexico, April 1936, by E. Matuda (no. 321).

This species superficially closely resembles *C. nelsoni* Scribn., which has shorter and broader blades, pubescent panicle axis, larger glumes, acuminate, sterile lemmas, and strongly nerved, sparsely pilose, fertile lemma.

[1] Received October 26, 1939. All drawings by Mrs. Frances C. Weintraub.

Chusquea longifolia Swallen, sp. nov.

Rami floriferi dense fasciculati adscendentes 20–60 cm longi; laminae 12–25 cm longae, 6–12 mm latae, marginibus scabris; paniculae 10–16 cm longae, angustae ramis gracilibus appressis paucifloris scabris; spiculae 12–13 mm longae appressae; glumae obtusae, enerves, prima 0.5 mm secunda 1 mm longa; lemma sterile primum 7–9 mm longum, 9-nerve, acutum, apiculatum, basi latum; lemma sterile secundum lemma fertile aequans, 9-nerve, acuminatum, superne scabrum; lemma fertile 11–12 mm longum, obscure nervosum, puberulum, acuminatum, minute bifidum, aristatum, arista 2–4 mm longa; palea lemmate fertili paulo longior, carinis approximatis, bidentata, marginibus latis.

Main culm about 5 mm thick (in flowering part) the flowering branches fascicled, ascending, 20–60 cm long; blades 12–25 cm long, 6–12 mm wide with scabrous margins; panicles 10–16 cm long, narrow, the slender branches appressed, scabrous, few-flowered; spikelets 12–13 mm long, appressed; glumes obtuse, nerveless, the first 0.5 mm long, the second 1 cm long; first sterile lemma 7–9 mm long, 9-nerved, acute, mucronate, very broad at the base; second sterile lemma as long as the fertile one, 9-nerved, acuminate, scabrous toward the tip; fertile lemma 11–12 mm long, obscurely nerved, puberulent, acuminate, minutely bifid, with an awn 2–4 mm long; palea as long as or a little longer than the lemma, bidentate, the keels approximate, the margins very broad, incurved.

Type in the U. S. National Herbarium, no. 1724503, collected on Mount Tacana, Chiapas, Mexico, altitude 2,000–4,088 meters, in August 1938, by E. Matuda (no. 2373).

Poa fibrata Swallen, sp. nov.

Perennis, rhizomatosa; culmi rigidi, erecti vel basi adscendentes, 15–35 cm alti, glabri vel scaberuli; vaginae inferiores tenues, lucidae, undulatae, fibrosae, glabrae, superiores internodiis longiores, firmae, scabrae; ligula 1–1.5 mm longa acute vel obtusa; laminae 4–8 cm longae vel supreme reductae firmissimae, conduplicatae, curvatae, scabrae, marginibus minute serratis; panicula 4–10 cm longa, densa, ramis brevibus appressis ad basin floriferis vel basi nudis, scabris; spiculae 3–4 florae, 5–6 mm longae; glumae acutae vel subobtusae, 1–3-nerves, prima 2–3 mm longa, secunda 3 mm longa; lemmata 2.5–3 mm longa, acuta vel subobtusa, glabra vel scabra vix pubescentia; palea subacuta, lemma subaequans; antherae 2 mm longae.

Perennial with slender, creeping rhizomes; culms 15–35 cm tall, rigid, erect from an ascending base, glabrous or scaberulous; lower sheaths thin, smooth and shining, undulate, becoming more or less fibrous with age, the upper sheaths longer than the internodes, firm, scabrous; ligule 1–1.5 mm long, acute or subobtuse; blades 4–8 cm long, or the uppermost sometimes reduced, very firm, conduplicate, curved, pungent, scabrous, the margins minutely serrate; panicle 4–10 cm long, dense, with short appressed branches floriferous to the base, or the lower ones sometimes naked at the base, scabrous; spikelets 3–4-flowered, 5–6 mm long; glumes acute or subobtuse, 1–3-nerved, the first 2–3 mm long, the second 3 mm long; lemmas 2.5–3 mm long, acute or subobtuse, glabrous or scabrous, sometimes rather obscurely pubescent near the base and on the margins; palea subacute, about as long as the lemma or a little shorter.

Type in the U. S. National Herbarium, no. 1646953, collected in a dry subsaline flat, 2 miles south of Grenada, Shasta Valley, Siskiyou County, Calif., altitude 2,600 feet, June 30, 1935, by Louis C. Wheeler (no. 3629).

Poa mulleri Swallen, sp. nov.

Perennis; culmi caespitosi erecti 25–40 cm alti, compressi; foliae prope basin congestae; vaginae carinatae glabrae, eae culmorum elongatae; ligula 0.5 mm longa, membranacea, truncata; laminae innovationum laxae, elongatae, involutae, eae culmorum planae, 3–6 cm longae, 1–2 mm latae, glabrae; paniculae 5–8 cm longae pyramidatae; rami solitarii vel bini, graciles, flexuosi, reflexi, ad 3 cm longi, basi nudi; spiculae biflorae, 4 mm longae; gluma prima 3 mm longa, 3-nervis, acuta, navicularis; gluma secunda 3.5 mm longa, 5-nervis, abrupte acuta; lemma inferius 3.5 mm longum, 5-nerve, acutum, carina et nervis marginalibus inferne pubescentibus; palea lemmate paulo brevior; antherae 2 mm longae.

Perennial; culms loosely cespitose, 25–40 cm tall, erect from an ascending base, conspicuously flattened; leaves mostly crowded toward the base of the culms; sheaths compressed keeled, glabrous, those of the culm elongate; ligule 0.5 mm long, truncate; blades of the innovations lax, elongate, involute, those of the culm flat, 3–6 cm long, 1–2 mm wide, glabrous; panicles 5–8 cm long, pyramidal, the branches solitary or in pairs, slender, flexuous, reflexed, the lower ones as much as 3 cm long, naked in the lower half; spikelets clustered on the upper half of the branches, appressed, short pediceled, 2-flowered; glumes navicular, the first 3 mm long, 3-nerved, the second 3.5 mm long, 5-nerved, usually rather abruptly acute; lower lemma 3.5 mm long, 5-nerved, acute, sparingly pubescent on the keel and marginal nerves toward the base; palea a little shorter than the lemma; anthers 2 mm long.

Type in the U. S. National Herbarium, no. 1645320, collected in pine woods on the Peak of Cerro Potosi, Municipio de Galeana, Nuevo Leon, Mexico, July 21, 1935, by C. H. Muller (no. 2251).

The very flat culms with short reflexed panicle branches are characteristic.

Stipa linearis Swallen, sp. nov.

Perennis; culmi graciles, dense caespitosi, erecti, 50–75 cm alti, 2-nodes; foliae ad basin dense congestae; vaginae culmorum elongatae internodiis breviores, subplanae, glabrae, eae innovationum breves, angustae; ligula

Fig. 1.—*Stipa linearis*, mature floret, ×1, and the body of the lemma, ×5.

brevissima vel ad 3 mm longa; laminae culmorum 3–10 cm longae, planae vel involutae, eae innovationum ad 35 cm longae, 1–1.5 mm latae, planae vel subinvolutae, infra glabrae supra scaberulae, marginibus scabris; panicula ad 13 cm longa, angusta, ramis gracilibus, appressis, paucifloris, 1–3.5 cm longis; glumae aequales 5 mm longae, acutae, prima 3–5-nervis, secunda 5-nervis; lemma 4–4.5 mm longum, fuscum, sparse pilosum; callum 0.5 mm longum, hebes, dense barbatum; arista 2 cm longa, bigeniculata.

Perennial; culms slender, densely cespitose, erect, 2-noded, 50–75 cm tall,

the numerous leaves of the innovations crowded toward the base in a dense cluster; culm sheaths elongate, shorter than the internodes, becoming almost flat, glabrous, those of the innovations short, narrow; ligule very short in the innovations, 1.5–3 mm long on the culm leaves; culm leaves 3–10 cm long, flat or involute, those of the innovations as much as 35 cm long, 1–1.5 mm wide, flat or subinvolute, glabrous below, scaberulous above, the margins scabrous; panicle up to 13 cm long, narrow, the slender appressed, few-flowered branches 1–3.5 cm long; glumes equal, 5 mm long, acute, green, hyaline toward the tip, the first 3–5-nerved, the second a little broader, always 5-nerved; lemma 4–4.5 mm long, abruptly narrowed to the asymmetrical summit, dark brown, sparsely pilose with pale or brownish hairs; callus 0.5 mm long, blunt, densely barbate; awn 2 cm long, somewhat obscurely twice geniculate.

Type in the U. S. National Herbarium, no. 1610598, collected in Diente Canyon, 12 miles south of Monterrey, Nuevo Leon, Mexico, July 13, 1933, by C. H. Muller (no. 433).

This species is closely related to *Stipa augustifolia* Hitchc., which is a smaller plant, 10–30 cm tall, with short involute blades and longer glumes and lemma.

Stipa acuta Swallen, sp. nov.

Perennis; culmi graciles caespitosi, erecti, ad 95 cm alti; vaginae internodiis breviores, glabrae; ligula 1.5–2 mm longa vel eae innovationum brevissimae; laminae involutae ad 23 cm longae, firmae, glabrae, marginibus scabris; paniculae longe exsertae, 15–20 cm longae, laxae, ramis gracilibus, adscendentibus vel divergentibus, basi nudis, paucifloris, ad 6 cm longis; spiculae appressae; glumae acutae, hyalinae, reticulatae, basi purpurascentes, prima 11–12 mm longa, 5-nervis, secunda 9–10 mm longa, 5–7-nervis; lemma 7 mm longum, fusiforme, fuscum, pilosum pilis albis appressis; callum 1 mm longum, pungens, dense pilosum; arista 4–4.5 mm longa, bigeniculata.

Perennial; culms slender, tufted, erect, about 95 cm tall; sheaths shorter than the internodes, glabrous; ligule 1.5 to 2 mm long, or very short on the innovations; blades involute as much as 23 cm long, firm, glabrous with scabrous margins; panicles long exserted, 15–20 cm long, lax, the slender ascending or spreading, somewhat flexuous glabrous branches naked at the base—usually in the lower half, few-flowered, as much as 6 cm long; spikelets appressed, the pedicels 2–5 mm long; glumes acute, hyaline, reticulate veined, tinged with purple at least toward the base, the first 11–12 mm long, 5-nerved, the second 9–10 mm long, 5–7-nerved; lemma 7 mm long, fusiform, very dark brown, rather densely appressed-pilose with white hairs; callus 1 mm long, sharp pointed, densely appressed pilose; awn 4–5 cm long, twice geniculate, scabrous, the terminal segment slender, somewhat flexuous, 3–3.5 cm long.

Type in the U. S. National Herbarium, no. 1760238, collected on rocky soil on Carneras Pass, 21 miles south of Saltillo, Coahuila, Mexico, September 1, 1938, by Forrest Shreve (no. 8545).

Stipa acuta is most closely related to *S. eminens* Cav., which has narrower, 3-nerved, acuminate glumes, a pale lemma 5–6 mm long, and a somewhat shorter awn.

Stipa diegoensis Swallen, sp. nov.

Perennis; culmi densi caespitosi, erecti, 70–100 cm alti, scaberuli, infra nodos densi pubescentes; vaginae inferiores internodiis longiores, superiores internodiis breviores, elongatae, glabrae vel scaberulae; ligula 1–2 mm longa,

obtusa vel truncata, ciliata, pubescens; laminae 15–40 cm longae, 2–4 mm latae, planae vel involutae, attenuatae, infra scaberulae, supra pubescentes; panicula 15–30 cm longa, densa, angusta, ramis appressis ad 10 cm longis; gluma prima 9–10 mm longa, 1-nervis, acuminata; gluma secunda 8–9 mm longa, 3-nervis, acuminata; lemma 6.5–7.5 mm longum, pilosum, pilis supremis 1–2 mm longis; callum 0.5 mm longum, curvatum, pungens, pilosum; arista 2–3.3 cm longa, bigeniculata, scabra; palea 4 mm longa, acuta, pilosa; antherae 4 mm longae, purpurascentes.

Perennial; culms densely tufted, erect, 70–100 cm tall, scaberulous, densely pubescent below the nodes; lower sheaths longer than the internodes, the upper ones shorter than the internodes, elongate, glabrous or scaberulous; ligule 1–2 mm long, obtuse or truncate, ciliate, pubescent; blades 15–40 cm long, 2–4 mm wide, flat or involute, scabrous on the lower surface, pubescent on the upper; panicle 15–30 cm long, narrow, dense, the

Fig. 2.—*Stipa diegoensis*, mature floret, ×1, and the body of the lemma, ×5.

branches appressed as much as 10 cm long; first glume 9–10 mm long, 1-nerved, acuminate; second glume 8–9 mm long, 3-nerved, acuminate; lemma 6.5–7.5 mm long, pilose, the hairs at the top of the lemma, 1–2 mm long; callus 0.5 mm long, curved, sharp-pointed, appressed pilose; awn 2–3.3 cm long, bigeniculate, scabrous; palea 4 mm long, acute, pilose; anthers 4 mm long, purple.

Type in the U. S. National Herbarium, no. 1761177, collected along vernal stream in chaparral, Proctor Valley near Jamul, San Diego County, Calif., May 23, 1938, by Frank F. Gander (no. 5778).

This species is apparently related to *S. editorum* Fourn., which is a much more slender plant, glabrous below the nodes and has thinner glumes, the second 1-nerved or obscurely 3-nerved, a shorter lemma 5–6 mm long, and a more slender obscurely geniculate awn.

Stipa bracteata Swallen, sp. nov.

Perennis; culmi ad 125 cm alti, caespitosi, erecti, 3-nodes, infra nodos dense retrorse pubescentes, infra paniculam bracteatae; vaginae internodiis breviores inferne pubescentes, in ore sparse pilosae; ligula 1.5–3 mm longa; laminae 25–40 cm longae, 1–3 mm latae, planae vel involutae, infra glabrae, supra pubescentes; panicula 35–42 cm longa, laxa, fasciculis ramorum remotis; rami graciles 4–10 cm longi adscendentes vel divergentes, basi nudi; spiculae appressae; glumae acuminatae, hyalinae, 3-nerves, prima 10–11 mm longa, secunda 8–9 mm longa; lemma 5.5–6.5 mm longum, fusiforme,

fuscum, pilosum pilis albis appressis; callum 0.5 mm longum, curvatum, dense barbatum; arista 20–24 mm longa, bigeniculata, glabra.

Perennial; culms as much as 125 cm tall, erect, tufted, 3-noded, densely retrorsely pubescent below the nodes, with a conspicuous ciliate bract 4–6 mm long below the panicle; sheaths shorter than the internodes, pubescent near the base, sparsely pilose at the throat, those of the innovations densely pubescent on the collar; blades 25–40 cm long, 1–3 mm wide, flat or involute, glabrous on the lower surface, pubescent on the upper; panicle 35–42 cm long, lax, the branches in small remote fascicles, 4–10 cm long, some long and some short in the same fascicle, slender, ascending or spreading, naked at the base, the longer ones usually spikelet bearing only near the ends; spikelets appressed; glumes acuminate, hyaline, 3-nerved, the first 10–11 mm long, the second 8–9 mm long; lemma 5.5–6.5 mm long, fusiform, brown, pilose with white appressed hairs; callus 0.5 mm long, somewhat curved, rather blunt, densely barbate; awn 20–24 mm long, bigeniculate, glabrous or nearly so, the two lower segments twisted, the upper straight.

Type in the U. S. National Herbarium, no. 1721797, collected on grassy flats 25 miles north of Ensenada, Baja California, April 4, 1931, by Ira L. Wiggins (no. 5153).

Stipa bracteata is related to *S. editorum* and *S. diegoensis* but is at once distinguished by the conspicuous bract below the panicle.

Digitaria albicoma Swallen, sp. nov.

Perennis; culmi caespitosi, erecti, 65–71 cm alti, simplices vel basi ramosi; vaginae inferiores internodiis multo longiores, dense villosissimae, superiores elongatae internodiis breviores, glabrae vel ad basin papilloso-pilosae;

Fig. 3.—*Digitaria albicoma*, spikelet and fruit, ×5.

ligula 1.5–2 mm longa, truncata; laminae planae, 10–30 cm longae, 3–5 mm latae, pilosae vel papilloso-pilosae, marginibus scabris; panicula longe exserta; racemi 5–9, graciles, adscendentes vel divergentes, 8–12 cm longi basi nudi; spiculae 2.5-mm longae, solitariae vel binae, inferior subsessilis, superior pedicello scabro 2 mm longo; gluma prima obsoleta; gluma secunda angusta 3-nervis, glabra, marginibus hyalinis; lemma sterile lemma fertile aequans, subobtusum, 5–7-nerve, glabrum, marginibus hyalinis; fructus 2.5–2.8 mm longus, acutus, plumbeus.

Perennial; culms cespitose, erect, 65–75 cm tall, simple, or branched at the base; lower sheaths much shorter than the internodes, densely villous, the upper ones elongate but shorter than the internodes, glabrous or papillose-pilose toward the base; ligule 1.5–2 mm long, truncate; blades flat, 10–30 cm long, 3–5 mm wide, pilose or papillose-pilose, the margins scabrous; panicle long exerted; racemes 5–9 slender, ascending or spreading, 8–12 cm long, naked at the base; spikelets 2.5 mm long, solitary or paired, the lower

one subsessile, the upper pedicellate, the pedicel 2 mm long, scabrous; first glume obsolete or nearly so; second glume narrow, 3-nerved, glabrous, the margins hyaline; sterile lemma as long as the fruit, 5–7-nerved, glabrous, the margins hyaline; fruit 2.5–2.8 mm long, acute, lead-colored.

Type in the U. S. National Herbarium, no. 1761179, collected in low open sandy woods, Chinsegut Hill Sanctuary, Brooksville, Hernando County, Fla., November 18, 1938, by Jason R. Swallen (no. 5644).

Digitaria albicoma is closely related to *D. subcalva* Hitchc., which has many noded culms decumbent at the base and sometimes rooting at the lower nodes, less conspicuously villous sheaths, and fewer appressed racemes.

Mesosetum comatum Swallen, sp. nov.

Perenne; culmi graciles, erecti, 50 cm alti; vaginae internodiis longiores, glabrae, in ore pilosae, marginibus minute ciliatis; laminae 4–6 cm longae, 2–2.5 mm latae, superiores et eae innovationum reductae, firmae, erectae, pungentes, infra glabrae, supra glabrae vel hispidae, marginibus sparse hispidis; gluma prima 3.5 mm longa, obtusa, basi hirsuta pilis ad 4 mm longis, in parte superiore scabra; gluma secunda 3 mm longa, 3-nervis, basi pilosa, superne glabra, marginibus breviter ciliatis; lemma sterile 4 mm longum, acutum, marginibus ciliatis pilis 2–2.5 mm longis, quam pilis glumae secundae crassioribus; lemma fertile 3.8–4 mm longum, minute striatum.

Perennial; culms slender, erect, about 50 cm tall; sheaths as long as or longer than the internodes with a small tuft of hairs in the throat and a pubescent line on the collar, the back glabrous, the margins finely ciliate; ligule about 0.2 mm long, ciliate; blades 4–6 cm long, 2–2.5 mm wide, the uppermost culm blades and those on the innovations much reduced, firm, erect, pungent, involute toward the tip, the lower surface glabrous, becoming hispid toward the tip, the upper surface glabrous or hispid, the margins sparsely papillose-hispid; raceme 7 cm long, erect; spikelets appressed; first glume 3.5 mm long, obtuse, obscurely keeled, not greatly narrowed toward the base, hirsute across the lower part, some of the hairs as much as 4 mm long, sparsely hirsute on the midnerve to the middle, the upper dorsal portion scabrous; second glume 3 mm long, 3-nerved, the tip rounded, glabrous on the back, pilose toward the base, the margins evenly appressed ciliate nearly to the summit; sterile lemma 4 mm long, acute, the margins densely ciliate, the hairs 2–2.5 mm long, coarser than those on the second glume; fruit 3.8 mm long, minutely striate.

Type in the U. S. National Herbarium, no. 1721241, collected at San Ignacio, Cerro Piedras, Province of Misiones, Argentina, March 10, 1914, by Rodriguez (no. 31). This specimen was communicated by L. R. Parodi, Buenos Aires, Argentina.

Mesosetum comatum resembles *M. loliiforme* (Hochst.) Chase, which is a stoloniferous plant with smaller appressed pilose spikelets, the sterile lemma not conspicuously fringed.

Panicum abscissum Swallen, sp. nov.

Perenne; culmi densi caespitosi, 55 cm alti, compressi; vaginae inferiores carinatae, 3–4 mm latae (e carina ad marginem), truncatae, ad basin culmorum congestae, superiores longiores, internodiis breviores, auriculatae; ligula curtissima; laminae 15–25 cm longae, 1–2 mm latae, conduplicatae, firmae, curvatae vel flexuosae, infra glabrae supra scaberulae; paniculae terminales et axillares, 7–15 cm longae, ramis adscendentibus vel appressis, paucifloris, ad 10 cm longis; pedicelli 1–4 mm longi appressi; spiculae 2.8–3

mm longae; gluma prima 1.6–2 mm longa, 3-nervis, acuta, carina scabra; gluma secunda et lemma sterile aequalia, 5-nervia, subobtusa, glabra; fructus 2.2–2.3 mm longus, 0.5 mm latus, acutus, pallidus, nitens.

Perennial; culms densely cespitose, 50–70 cm tall, compressed; lower sheaths keeled, somewhat crowded, 3–4 mm wide from keel to margin, one side of the sheath sometimes 5–8 mm longer than the other, truncate or extended at the summit into short, very broad, obtuse auricles, the upper sheaths much longer than the lower but much shorter than the internodes, the auricles not so prominent; ligule membranaceous, very short; blades 15–25 cm long, 1–2 mm wide, conduplicate, firm, curved or flexuous, glabrous on the lower surface, scabrous on the upper; panicles terminal and axillary from all the nodes, long exserted, 7–15 cm long, the branches ascending or appressed; spikelets 2.8–3 mm long; first glume 1.6–2 mm long, 3-nerved, acute, scabrous on the keel; second glume and sterile lemma equal,

Fig. 4.—*Panicum abscissum*, spikelet and mouth of sheath, ×5.

5-nerved, subobtuse, glabrous; fruit 2.2–2.3 mm long, 0.5 mm wide, acute, pale, smooth and shining.

Type in the U. S. National Herbarium, no. 1259952, collected in dry sand at tourist camp near lake, Sebring, Fla., October 3, 1925, by Paul Weatherwax.

Panicum abscissum belongs to the *Agrostoidea* group of *Panicum*. It is distinguished from all the other species of the group by the broad sheaths truncate at the summit, the firm flexuous blades, and the axillary panicles from all the nodes.

DISTRIBUTION: Sandy or swampy ground, central Florida. De Soto County: Sebring, *Weatherwax* in 1925 (type); Polk County: Winter Haven, *O'Neill* 5207, 5208; Florinda, *Piper* in 1917.

Panicum irregulare Swallen, sp. nov.

Perenne; culmi 80 cm longi, prostrati, ramosi, radicantes, glabri; vaginae internodiis breviores vel superiores internodiis longiores, glabrae, in ore pubescentes; laminae 4.5–6.5 cm longae, 1–1.5 cm latae, ovato-lanceolatae, acuminatae, glabrae, marginibus albis; paniculae 16–17 cm longae, racemis 15 remotis adscendentibus 1–2.5 cm longis; spiculae biflorae, binae, 2–2.2 mm longae, prima subsessilis, secunda pedicellata; gluma prima 0.7–1 mm longa, 1-nervis, acuta; gluma secunda et lemma flosculi primi subaequalia,

acuta, 5-nervia, glabra; palea flosculi primi 1.5 mm longa, hyalina; caryopsis libera; fructus 1.5 mm longus, acutus, lucidus.

Perennial; culms 80 cm long, prostrate spreading, ascending at the ends, branching, rooting at the lower nodes; sheaths shorter than the internodes or the upper ones a little longer than the internodes, glabrous, pubescent at the mouth; blades short pedicellate, 4.5–6.5 cm long, 1–1.5 cm wide, ovate-lanceolate, acuminate, with white cartilaginous margins; panicles 16–17 cm long with 15 rather remote ascending racemes 1–2.5 cm long; spikelets rather densely arranged on one side of the rachis, 2-flowered, paired, 2–2.2 mm long, spreading, the first subsessile, the second pedicellate; first glume 0.7–1 mm long, 1-nerved, acute; second glume and lemma of the first floret similar, subequal, acute, 5-nerved; palea of first floret 1.5 mm long, hyaline; caryopsis free; fruit 1.5 mm long, acute, smooth and shining.

Type in the U. S. National Herbarium, no. 1644874, collected on stony river bank in the vicinity of El General, Province of San Jose, Costa Rica, altitude 760 meters, February 1939, by Alexander F. Skutch (no. 4115).

Panicum irregulare is related to *P. frondescens* Meyer, which has a denser, shorter panicle of more numerous racemes and larger spikelets 2.6–2.8 mm long with the lower floret sterile.

BOTANY.—*Arizona plants: New species, varieties, and combinations.*[1]

F. J. HERMANN, T. H. KEARNEY, and R. H. PEEBLES, U. S. Bureau of Plant Industry.

A paper on this subject appeared in this JOURNAL on November 15, 1939 (**29**: 474–492). A few additional novelties have since come to light, and they are published here in order to avoid publication of new names in a flora of Arizona, now in preparation.

Juncus interior Wieg. var. **arizonicus** (Wieg.) Hermann, comb. nov.

Juncus arizonicus Wieg., Bull. Torrey Bot. Club **27**: 517. 1900.

Juncus interior Wieg. var. **neomexicanus** (Wieg.) Hermann, comb. nov.

Juncus neomexicanus Wieg., Bull. Torrey Bot. Club **30**: 447. 1903.

Both *J. arizonicus* and *J. neomexicanus* possess the acuminate to aristate bracteoles of *J. interior*, which set this species off from its nearest allies. Intermediates are frequent between the two varieties here proposed and typical *J. interior*, but most material falls rather readily into one of the three forms and may be distinguished by the following key:

Perianth equaling the capsule, 3–4 mm long ..... *J. interior*

Perianth exceeding the capsule, 4–5 mm long.

Bracteoles lanceolate, acuminate; perianth-segments erect, rigid, lanceolate, their hyaline margins relatively narrow and opaque .... *J. interior* var. *arizonicus*

Bracteoles broadly ovate, acute to abruptly aristate; perianth-segments spreading, not rigid, broadly ovate, with broad transparent scarious margins and brown lateral bands bordering the green center .... *J. interior* var. *neomexicanus*

[1] Received February 1, 1940.

Juncus longistylis Torr. var. **scabratus** Hermann, var. nov.

A varietate typica recedit foliis pedicellisque scabratis.

Of the 20 collections of *J. longistylis* seen from Arizona, 9 represent the typical form of the species and, except for one specimen from the Huachuca Mountains (Cochise County), all are from the northern half of the State. The others have the vegetative parts scabrate much as in the eastern *J. caesariensis* Coville, and the auricles show a tendency to be prolonged, free, and acute. The scabrosity is most conspicuous upon the pedicels and the terminal portions and margins of the leaves. Intergradations with the typical form are found in various degrees, however. The following collections in the U. S. National Herbarium are characteristic of var. *scabratus:* Near Prescott, alt. 5,350 feet, Yavapai County, *Peebles, Harrison, & Kearney* 2712, August 8, 1926 (TYPE); Willow Springs, Apache, County *E. Palmer* 556 (in part) and 624 (in part), July 1890.

Juncus tracyi Rydb. f. **utahensis** (Martin) Hermann, comb. nov.

J. utahensis Martin, Rhodora **40**: 69–71. 1938.

Juncus tracyi manifests two forms, a few-headed, many-flowered phase, characterized by the type specimen of Rydberg's species, and a many-headed, few-flowered phase, represented by the type specimen of *J. utahensis*. The extremes of these forms are strikingly different in appearance yet intermediates are plentiful and there is no apparent geographic segregation of the extremes. *Juncus ensifolius* Wikstr., *J. phaeocephalus* Engelm., *J. saximontanus* A. Nels., *J. canadensis* J. Gay, and *J. acuminatus* Michx. are other species that exhibit a parallel series of forms.

Juncus saximontanus A. Nels. f. **brunnescens** (Rydb.) Hermann, comb. nov.

Juncus brunnescens Rydb., Bull. Torrey Bot. Club **31**: 400. 1904.

This form shows the same instability as does *J. tracyi* f. *utahensis* and like it seems to have no geographic significance. The extremes may be distinguished by the following key:

Inflorescence composed of few (seldom more than 10) heads, which average 7–10 mm in diameter and are many (15 to 25)-flowered..... ..... *J. saximontanus*

Inflorescence composed of numerous (usually more than 10) heads, which average 5–6 mm in diameter and are few (5 to 12)-flowered..... ..... *J. saximontanus* f. *brunnescens*

Astragalus cobrensis Gray var. **maguirei** Kearney, var. nov.

Ab *A. cobrensi* f. typica pilis longioribus patentibus, foliolis supra parce pubescentibus, calycis dentibus quam tubo longioribus, recedit.

Type from White Tail Canyon, Chiricahua Mountains, Cochise County, Ariz., in sandy soil under oak and walnut, *Bassett Maguire et al.* 11079, May 2, 1935 (U. S. National Herbarium no. 1768940).

The variety here described has rather long spreading hairs on the herbage and pods, leaflets sparsely pubescent above, and calyx with teeth longer than the tube, whereas in typical *A. cobrensis* the hairs are shorter and appressed, the leaflets glabrous above, and the calyx-teeth about as long as the tube. The flowering stems in var. *maguirei* (probably also in *A. cobrensis*) arise from long, slender, creeping rootstocks.

Astragalus cobrensis, known only from southwestern New Mexico, is sparingly represented in herbaria, and var. *maguirei* is known only by the type collection. Study of additional material of these forms may prove *maguirei* to be a distinct species.

Echinocereus robustus Peebles, sp. nov.

Echinocereus rectispinus Peebles var. *robustus* Peebles, Amer. Journ. Bot. 25: 675. 1938.

ZOOLOGY.—*The hairworm,* Gordius robustus *Leidy, as a parasite of the Mormon cricket,* Anabrus simplex *Haldeman.*[1] GERALD THORNE, U. S. Bureau of Plant Industry.

INTRODUCTION

Parasites effective against the Mormon cricket, *Anabrus simplex* Haldeman, apparently are very rare. It was, therefore, of considerable interest when there were reports of a heavy parasitism by *Gordius robustus* Leidy in the vicinity of Arrowrock Dam, Idaho (1). Visits to that locality were made by the writer on July 26 and October 9, 1935, and on May 16 and August 24, 1936. The unusual populations occurring there presented excellent opportunities for studying the parasite from the standpoint of life history, habits, host relationship, ecology, and economic importance. Specimens for more detailed examination and experiments were taken to the Salt Lake City, Utah, laboratory.

This observation of *Gordius robustus* coincided with the unprecedented populations of *Anabrus simplex* which first appeared at Fort Hall, Idaho, in May, 1932, and by August, 1936, had infested almost 2,000,000 acres in 24 counties of Idaho (11). Similar outbreaks of the cricket occurred in other western States (Fig. 1).

HISTORICAL

Gordius robustus Leidy, 1851, belongs to the rather common group of organisms known as "hairworms," the adults of which are usually found inhabiting warm shallow pools or streams. In its immature stages it is known as a parasite of certain insects, principally Orthoptera.

The first record of *Gordius robustus* in *Anabrus simplex* (synonym *A. pur-*

[1] The writer is indebted to Claude Wakeland and R. W. Haegele, who gave valued preliminary information on the distribution of *Gordius robustus* in the Arrowrock section and joined in visiting the area on two occasions. J. Percy Moore, of the University of Pennsylvania, kindly lent the Leidy collection of *G. robustus* from Milk River, Mont., and Dr. Henry B. Ward forwarded the May collection from Urbana, Ill., for comparison with the Idaho and western Montana specimens collected in 1935. G. Steiner and Edna M. Buhrer have given valuable suggestions on the manuscript and bibliography. The map used in Fig. 1, giving the 1937 distribution of *Anabrus simplex*, is taken from a U. S. Department of Agriculture Press Service release, March 26, 1937. Received November 18, 1939.

purascens[2]) is given by Riley, Packard, and Thomas (9, footnote 83, p. 327), who mention "*Gordius robustus*, Leidy.—A ♂ from ♀ *Anabrus purpurascens* Uhler; in Mr. Riley's cabinet." No records remain as to the locality in which this specimen was collected. Riley, Packard, and Thomas (10, p. 64) quote Bruner's remarks on parasites of the Mormon crickets observed along the Portneuf River, Idaho: "Hair-worms (*Gordius*), too, are frequently found wound about their intestines."

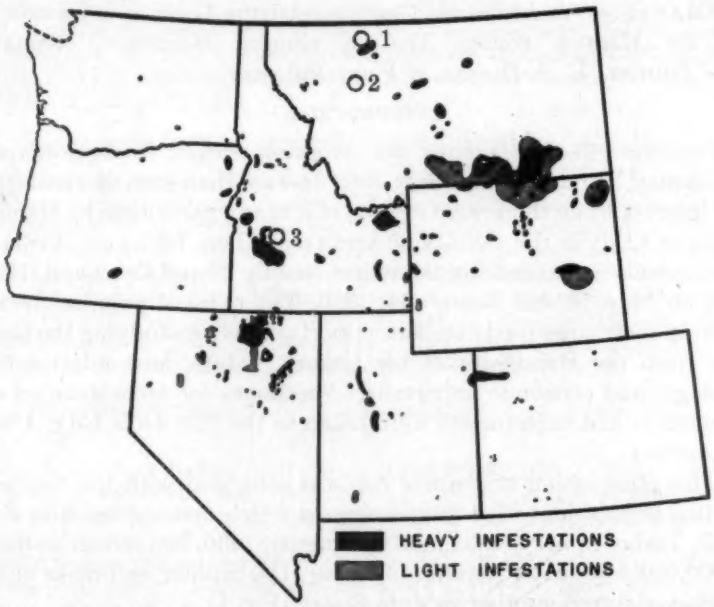

Fig. 1.—Range of *Anabrus simplex* in 1937 and known distribution of *Gordius robustus:* 1, Cutbank, Mont.; 2, Augusta, Mont.; 3, Arrowrock Reservoir, Idaho.

Leidy (3) reported *Gordius robustus* from New Jersey as a parasite of a grasshopper, later (5) identified as *Conocephalus fasciatus fasciatus* (DeGeer) (synonym *Orchelimum gracile* Harris), and (4) of the carabid beetle *Pterostichus* (*Gastrellarius*) *honestus* Say (synonym *Pterostichus fastiditus* Dej.). Thomas (9) found a female in *Stenopalmatus fuscus* Haldeman (synonym *S. fasciatus* Thomas) at Wasatch, Utah. May (6) reports it in the vicinity of Urbana, Ill., as a frequent parasite of *Orchelimum vulgare* Harris, *O. nigripes* Scudder, *Conocephalus memoralis* (Scudder) (synonym *Xiphidium nemorale* Scudder), and occasionally *Phaneroptera furcata furcata* (Brunner) (synonym *Scudderia furcata* Brunner).

[2] Synonyms given are the host names of the original records.

THE IDENTITY OF GORDIUS ROBUSTUS LEIDY, 1851

The type specimen of *Gordius robustus* from *Concocephalus fasciatus fasciatus* has not been preserved, but a collection from Milk River, Mont., made in 1876 and identified by Leidy, is still available. This consists of four males and six females varying from 31 to 46 cm in length. The hosts of these specimens are unknown, but they were collected within the range of *Anabrus simplex* and, judged from their size, it appears quite probable that they grew in these large insects. These 10 specimens are identical to those recently collected in Idaho and Montana except for their lighter color, which is due to bleaching during their long preservation in alcohol.

Leidy's original designation of the name *Gordius robustus* was given with a very meager description (3). Later (4, p. 57) he published a more detailed description but listed the species as a synonym of *G. aquaticus?* Gmelin (which is *G. aquaticus* Linn., 1758). He followed the name with a question mark, indicating that his specific designation was questionable. Montgomery (7) placed the species as a variety, *G. aquaticus robustus;* but later (8) made it a synonym of *G. villoti* Rosa, 1882. May (6) considered *G. robustus* as a valid species and prepared an excellent, detailed morphological description.

After examining the specimens from Milk River, Mont., the writer considers that May's action was fully justified. To further establish the fact, specimens from the Arrowrock section were sent to Kurt Heinze, a leading European authority on Gordioidea, who pronounced them as being neither *Gordius aquaticus* nor *G. villoti.*[3] Caballero (2) records both *G. robustus* and *G. aquaticus* from Mexico, thus supplying additional evidence that the two species are distinct.

Since Leidy determined the specimens from Milk River, Mont., as being the same as his type specimen of *Gordius robustus* from New Jersey and also in view of the fact that May found the species prevalent in Illinois, the writer has no basis for assigning the form to any other species.

DISTRIBUTION OF GORDIUS ROBUSTUS AS A PARASITE OF ANABRUS SIMPLEX

A survey of the Arrowrock section on July 26, 1935 (Fig. 2), revealed that there was a great difference in the number of *Gordius* present in the various localities. They were most numerous on Elk Creek where tangled masses (Fig. 3) were present in almost every pool, and many more were scattered along the stream or buried in the loose gravelly soil or under rubbish. At Grouse Creek and near Long Gulch Ranger Station they were almost as numerous, while small numbers were present in Slide Gulch, Cottonwood, Highland Valley, and other points along the route.

After the first reports of the parasitism of Mormon crickets by a *Gordius*, workers in the various cricket infested areas of the Western States were on the alert for additional localities in which the hairworm might be present.

[3] Personal communication dated February 20, 1937.

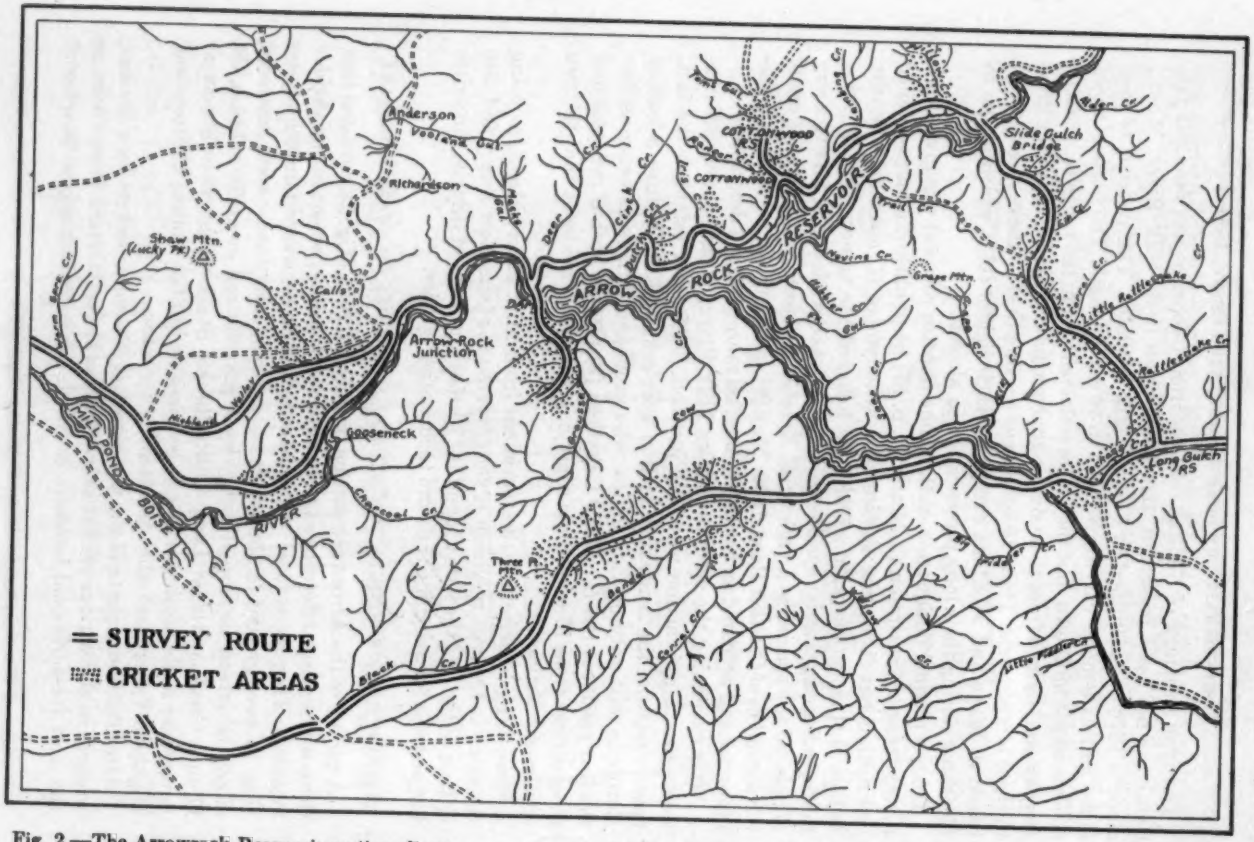

Fig. 2.—The Arrowrock Reservoir section showing survey route, July 26, 1935, and location of Mormon-cricket bands at that time.

However, the only places added were in Montana, where Frank Cowan and Horace J. Shipman, of the U. S. Bureau of Entomology and Plant Quarantine, collected a considerable number near Cutbank and a single female near Augusta (Fig. 1).

ECONOMIC IMPORTANCE OF GORDIUS ROBUSTUS

Reliable reports indicate that between 25 and 50 percent of the Mormon crickets invading the Grouse Creek section early in July 1935, were para-

Fig. 3.—Entangled mass of *Gordius robustus* collected on upper Elk Creek.

sitized by *Gordius robustus*, and this appeared to be corroborated by the great numbers present in the stream and buried in wet areas. At that time on Arrowrock Reservoir the crickets entered the water in great numbers, until patches 2 or 3 square rods in extent sometimes were floating about and from them large numbers of Gordii emerged and congregated along the shore. By July 26 it was evident that the larger portion had left their hosts, and it was difficult to find crickets in which Gordii still remained; between Arrowrock Dam and Grouse Creek only five parasitized crickets were found among 1,000 examined, and in other localities they were just as rare. However, the

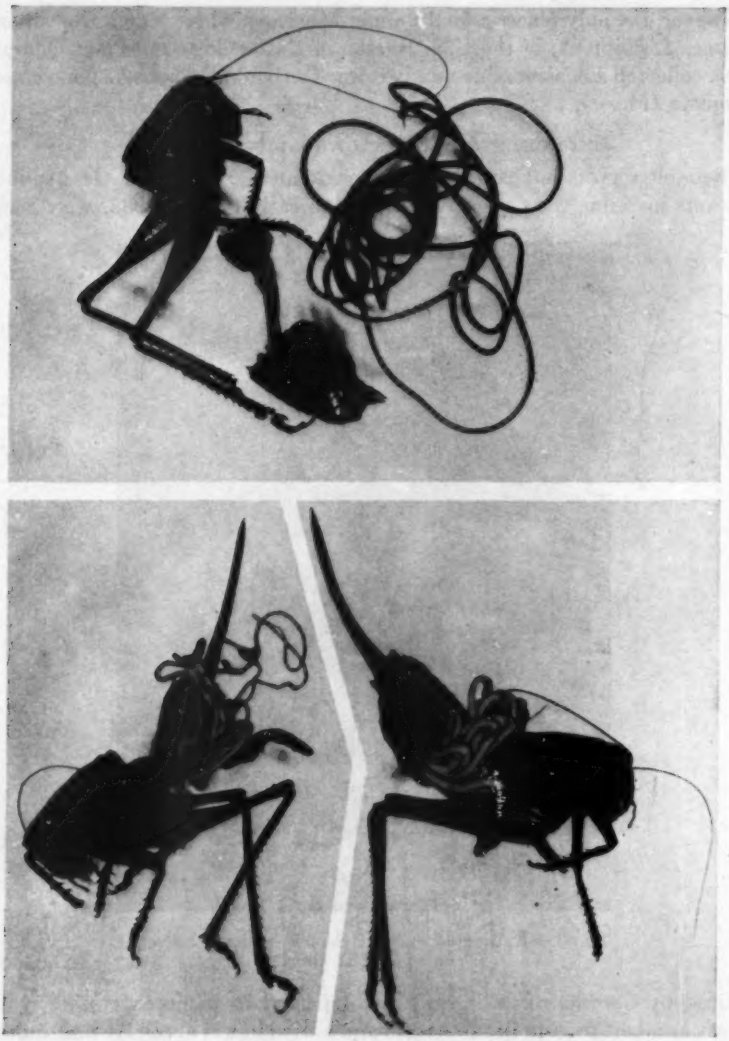

FIG. 4.—*Anabrus simplex* parasitized by *Gordius robustus*. Note in the top figure how thoroughly the body contents of the insect have been absorbed, leaving only the alimentary canal. Natural size.

crickets are migratory, remaining in one locality only a short time, and it is probable that those observed by the writer were from different breeding areas than those in the earlier invasions.

Commenting on the parasitized crickets collected on September 26, 1935,

near Cutbank, Mont., Horace J. Shipman wrote, "The parasitized crickets were found near a pond, which was the only one in the vicinity. Crickets taken within 100 yards of the pond were approximately 99 percent parasitized, and only one of the crickets contained eggs. One mile north of this pond the crickets were about 50 percent parasitized."[4]

On July 20, 1936, Claude Wakeland[5] reported that about one-fourth of the crickets in the Slide Gulch and Rattlesnake localities near Arrowrock Reservoir were parasitized.

None of the parasitized crickets collected by the writer contained eggs. The body cavity was invariably found to be completely filled with the parasite, and only the alimentary canal remained (Fig. 4). The parasitized female containing a few eggs reported above by Shipman may have been a case of very late parasitism after the ovaries had been developed.

It is evident that female crickets parasitized by *Gordius robustus* rarely produce eggs; therefore, in regions of heavy parasitism the cricket population must be considerably reduced. Since only a minor portion of the breeding grounds of the Mormon cricket lies near streams, ponds, and swamps suitable for the propagation of *Gordius*, the effective control exercised over the total cricket population during extensive outbreaks probably is negligible. The migratory habits of the cricket bring great numbers to streams where they may become parasitized but at the same time a large portion of these individuals wander far from water and die, the parasites being lost because water is essential to completion of their life cycle.

During the many years between extensive cricket outbreaks only small bands occur, and these generally are confined to the higher elevations where there is more abundant moisture. In those regions where *Gordius* is abundant the water-frequenting habits of the crickets no doubt bring practically all of them in contact with *Gordius*, and during such periods it seems quite probable that economically more effective parasitism occurs.

MORPHOLOGY OF GORDIUS ROBUSTUS

Adults.—But little can be added to May's description of the adults (6). The specimens observed all correspond closely with his observations except in minor points, which apparently are due to individual variation. Very light-colored specimens, especially females, apparently lack the dark dorsal and ventral bands and light-colored areas of the cuticle that May mentions, but they show distinctly on all the darker-colored females and males. These markings were also absent on the bleached, alcohol-preserved specimens from the Leidy collection. The branching hairs of the cuticle mentioned by Montgomery (7) could not be found, and since May also failed to observe them this statement must have been an error. Considerable variation in the male postcloacal ridge occurred among the specimens collected,

[4] Personal communication dated December 9, 1935.
[5] Personal communication dated June 20, 1936.

the most common form being slightly angular (Fig. 5, A), while a more angular type (Fig. 5, B) was comparatively rare.

The oral opening is degenerated to a minute scar (Fig. 5, C), which is visible only in a face view. In no instance was it observed that the larval spear remained within the oral aperture.

A brownish ring generally surrounds the cloacal opening of the female, but on occasional specimens it is entirely lacking. When present it varies considerably in its distinctness and width.

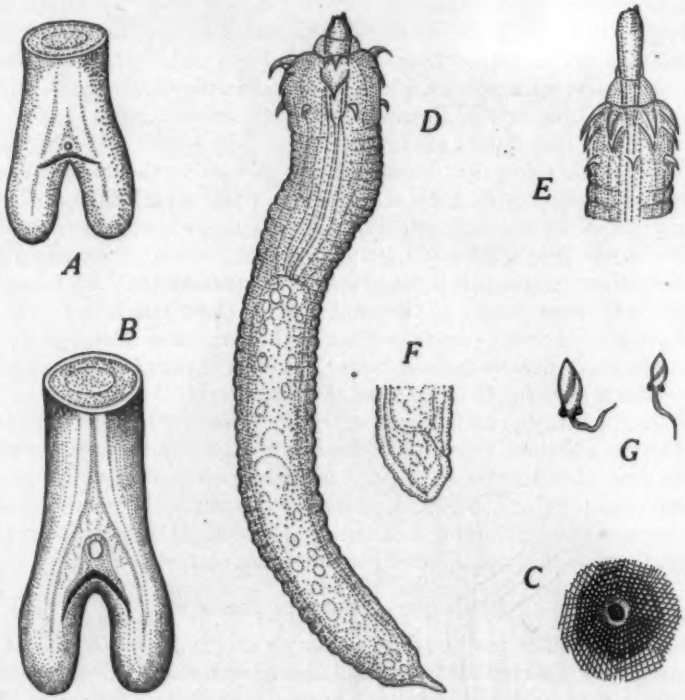

Fig. 5.—A, B, Male tails showing variations in the form of the cloacal ridge, ×25. C, Rudimentary oral opening, ×750. D, Larva, ×750. E, Head of larva with protruded proboscis, ×750. F, Posterior portion of larva with blunt terminus, ×750. G, Sperms, ×1500.

Specimens of *Gordius robustus* from *Anabrus simplex* frequently are very large. Wakeland and Shull (11) state that they reach a length of 48 inches (121.9 cm), and the writer collected a female 120.6 cm long. A random collection of 200 specimens contained 63 females varying in length from 13 cm to 120 cm and 137 males from 18 cm to 91 cm.

Eggs.—The slightly ovate eggs average about 38μ wide by 51μ long and are deposited in slender broken cords held together by a gelatinous mucus,

which swells on contact with water until the egg cord is about 1 mm in diameter (Fig. 6, A). The ovary occupies almost the entire body cavity, and the number of eggs produced by a female is enormous, those from a 106-cm female being estimated at 28,902,500. There is a short uterus, 2 to 3 mm long, in which huge numbers of minute spermatozoa (Fig. 4, G) can be found in fertilized females. The body of the spermatozoon appears to be somewhat flattened and concave, probably giving it a rotary motion as it is propelled by its tail. Fertilization of the eggs occurs as they pass through the uterus.

Fig. 6.—A, Egg cord after deposition, ×1.
B, Female hibernating among roots, ×1.

Eggs are regularly deposited in spring, but rare females occasionally were observed depositing in fall. Segmentation and larval development may occur immediately or be delayed for some months.

LIFE CYCLE OF GORDIUS ROBUSTUS IN THE ARROWROCK SECTION

Overwintering females emerge from their hibernating quarters in the loose gravelly soil or under sticks, stones, and rubbish (Fig. 6, B) during April and May and enter the shallow water of swamps, pools, or streams where the eggs are deposited. Many of the eggs hatch soon after deposition,

while others may remain for several months without hatching. Some of these taken to Salt Lake City contained living larvae until September, and it is doubtful if they would have hatched that fall.

The minute larvae move slowly about in the water, frequently lifting themselves up on the tips of their tails and swinging about in circles. Here they apparently are picked up by the young crickets when drinking, or when eating aquatic plants, and pass to the intestine. Presumably they force their way through the intestinal wall into the body cavity with the toothed proboscis while they cling to the intestinal tissues by means of the three rows of cephalic hooks.

After entering the body cavity growth takes place so rapidly that by late in June many are full grown and ready to emerge from the crickets. Apparently the time of leaving the host depends upon some sense of proximity to water, for during the heat of the day, when crickets congregate in the shade along streams or moist areas, the mature *Gordius* break through the abdominal wall and emerge, moving into the water or burying themselves in the moist soil.

At the time of emergence from the host the color of the females varies from a milky white to light brown, and that of the males from light to dark brown. After exposure to light the color deepens, especially in the males, which are usually darker than the females, sometimes almost black.

Copulation takes place in the water, perhaps also in the soil, soon after emergence. Females collected July 26 usually contained sperms in the uterus.

Larvae.—The larvae (Fig. 5, D) range in length from 0.12 to 0.16 mm and average about one-ninth as wide as long. The flexible cuticle is marked by annules that vary in distinctness and width as the individual moves about. The broad anterior end bears three circlets of cephalic hooks, the second row is arranged directly behind the first, while the third row alternates, the hooks being back of the interspaces of the first two rows. When at rest these hooks are retracted into the oral opening until the last row points almost straight forward. As the proboscis is extruded the hooks roll out and back (Fig. 5, E).

The slightly clavate proboscis bears two or three very minute projections on its distal end. Back of these, on the anterior conoid portion, are about six rows of fine corrugations. The proboscis joins the tubular esophagus, their combined length varying from one-eighth to two-fifths that of the entire body.

The larvae generally have a pointed tail, but occasional specimens had blunt, rounded tails (Fig. 5, F).

The larvae are soft bodied and unable to withstand drying. Exposure to air on a bamboo splinter for one minute was fatal in every case.

The manner in which the larvae of *Gordius robustus* enter *Anabrus simplex* was determined by the following method: A supply of crickets was secured near Tooele, Utah, where *G. robustus* is not known to occur. Lettuce was fed to the crickets, and as soon as one was busily feeding a drop of water con-

taining several larvae of *G. robustus* was placed just in front of it. Generally the cricket continued feeding and swallowed the larvae along with the food.

Thirty crickets were fed in this manner on June 15 to 18 and placed in a cage. A few crickets were removed each week thereafter, three to five at a time, and dissected. On July 1, one female contained a male *Gordius* 260 mm long and on July 9 another female was found with a male *Gordius* 245 mm long. Of the 30 crickets, 18 died and 12 were dissected. Only the two mentioned were parasitized.

At the same time 23 crickets were selected, and a drop of water containing several larval *Gordius* was placed in the folds between the sclerites of the abdomen. Of these 23 crickets, 9 died and the remainder were dissected, none being found infested. Because of their sensitiveness to drying it would appear impossible for the larvae to enter the body of the host in any manner other than through the mouth.

Unfortunately the season was so far advanced that very young crickets could not be secured, and those used in the above experiments were all in the second and third instars. In these large crickets the larval *Gordius* apparently are carried through the intestinal tract before they have an opportunity to penetrate the intestinal wall. This appeared to be proved by the fact that among 50 adult crickets confined in wet swampy pens, in which thousands of *Gordius* eggs and larvae were kept in excellent condition, not one became parasitized. An abundance of small aquatic plants was present and these, together with the water consumed, certainly would appear to have given every cricket ample opportunity to become parasitized.

ECOLOGICAL FACTORS

In the postparasitic stages *Gordius robustus* thrives best in warm shallow pools with loose gravelly banks well covered with vegetation. These conditions enable them to congregate during the mating season and later work their way into the loose soil, under stones and sticks, or into masses of roots or leaves, where they hibernate during winter. Seep areas where warm ground water rises during winter are especially favorable, and in the Arrowrock Dam section these areas were generally inhabited by large numbers.

In the years preceding these investigations such conditions had prevailed in the Arrowrock section. There had been no unusual runoff and the stream beds were littered with sticks, pieces of logs, and loose stones, making ideal breeding conditions for *Gordius robustus* (Fig. 7, A).

The months of January and February, 1936, were unusually cold, each with average mean temperatures of 23.4° F., 1.7° and 7.4° respectively below the normal at the Arrowrock Reservoir station. This temperature was accompanied by a heavy snowfall with a water content of 10.14 inches, 4.87 inches above the mean for these two months. As a result the loosely packed snow melted rapidly during March and especially during April. Streams flooded over their banks, channels were widened and deepened, and all

Fig. 7.—A, Upper Elk Creek, Idaho, July 26, 1935.
B, Same location, May 16, 1936.

debris was removed (Fig. 7, B). Most of the hairworms that had hibernated in the stream channels and adjacent banks were carried away by these floods. Scores of them could be found hanging high on limbs and roots where they had been left as the waters receded. As a result the *Gordius* population in the Elk Creek and neighboring basins was estimated to be

only 5 to 10 percent as great as in the preceding year. Many years will be required to repair the erosion damage to these stream beds and return them to their former conditions, which were so favorable as breeding grounds for *Gordius*.

SUMMARY

The hairworm *Gordius robustus* was first observed as an important parasite of the Mormon cricket, *Anabrus simplex*, in 1935 in the vicinity of Arrowrock Reservoir, Idaho. In certain localities of this area there are favorable breeding grounds for the hairworm along small mountain streams and in pools or swamps. In these localities they may be of economic importance in the control of ordinary populations of Mormon crickets. However, during heavy outbreaks of crickets, such as occurred in 1935 to 1937, the percentage of parasitism was too small to be of economic importance, although in some instances it reached 25 to 50 percent of the crickets. Similar parasitism was also observed near Augusta and Cutbank, Mont., where in certain small areas 50 to 99 percent of the crickets contained Gordii.

Parasitized crickets rarely produce eggs. They live normally until the mature *Gordius* breaks through the abdominal wall and enters water or wet soil. Here the Gordii mate and later hibernate in moist places under sticks and stones or among roots and rubbish. Some eggs are deposited in fall but more generally in spring, when the females emerge from hibernation and deposit them along the shores of streams, ponds, or swampy areas. Here the minute larvae hatch and probably are picked up by the young crickets when drinking water or eating aquatic vegetation. Upon reaching the intestine of the cricket they apparently bore through the wall and enter the body cavity, remaining there until maturity.

Under present erosion conditions in breeding areas of the *Gordius* most of them are carried away by floods.

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SCIENTIFIC NOTES AND NEWS

CONFERENCE ON A NEW FLORA OF THE DISTRICT OF COLUMBIA

A conference on a new flora of the District of Columbia (to replace the one published in 1919) was held at George Washington University, February 20, 1940.

An Executive Committee was appointed to administer the venture. The chairman of this committee is E. H. WALKER, of the U. S. National Herbarium, and the other members are C. R. BALL, Extension Service, U. S. Department of Agriculture; AGNES CHASE, Smithsonian Institution; ROBERT F. GRIGGS, George Washington University; NEIL HOTCHKISS, U. S. Biological Survey; and HUGH O'NEILL, Catholic University.

The conference discussed the area to be included in the new flora, and though no final decision was taken it was the consensus that the limits be extended beyond those established for the current flora. It will be several years before the new flora goes to press, and the intervening period will be utilized in collecting. The George Washington University has provided space, with tables and storage cases, in which several botanists have offered to deposit their local collection.

All those desirous of participating in this enterprise should communicate with E. H. WALKER.

Obituary

FREDERICK GALE TRYON, economist, National Bituminous Coal Commission, died on February 15, 1940. Mr. Tryon was born in Minneapolis, Minn., in 1892. He was graduated from the University of Minnesota with an A.B. in 1914, and in 1916 he received his A.M. degree from that institution. Later he did additional graduate work at Johns Hopkins University. In 1916 and 1917 he was employed as an assistant geologist with the Empire Gas & Fuel Co. During the Great War he was commissioned as a captain and assigned to the statistics branch of the General Staff of the Army in Washington and with G.H.Q. in France, and later was American secretary for the raw materials section, Supreme Economic Council, American Peace Commission, Paris, 1919. In 1920 to 1925 he served as a mineral geographer in charge of coal and coke statistics for the U. S. Geological Survey. During a part of this time, from 1922 to 1923, he further acted as statistical adviser to the U. S. Coal Commission. From 1925 to 1937 he was connected with the U. S. Bureau of Mines in fuel industries, during 1936 and 1937 as principal economist. In 1937 he was appointed economist in the Bureau of Research and Statistics, National Bituminous Coal Commission.

Mr. Tryon served on the staff of various institutions including the University of Pennsylvania, Brookings Institution, American University, and the Institute of Economics (Washington, D. C.). He was appointed on the President's Research Committee to study social trends in 1932–1933, and in 1934–1935 to study population redistribution.

In addition to the Washington Academy of Sciences Mr. Tryon was a member of the Economics Association, the American Institute of Mining and Metallurgical Engineers, the Mining and Metallurgical Society, the Geological Society of Washington, and the American Association for the Advancement of Sciences and was a fellow of the Statistical Association.